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PART II: SCIENCE, POLICY, AND REGULATION

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PART II: SCIENCE, POLICY, AND REGULATION

MR. YERGIN: That's a great introduction. Thank you.

I want to congratulate Strobe, Bill, and the entire Brookings team for pulling together this exceptional, timely, and very rich in content conference. I think we all benefit from it. And I just want to do them a slight favor, because they're too modest to do it. This book *Fast Forward* is a really good book. It's incredibly timely. It went to press just within the last couple of weeks, and I urge everyone to have their copy. It brings a lot to bear, and it bring it very much -- it gives a real perspective for the kind of discussion that's happening here and the discussion that will unfold around the world in the months ahead.

So, I'm very pleased to introduce another Brookings alumnus, as Strobe has already pointed out. David Sandalow is a senior fellow in the Foreign Policy Study Program Institution. David has a very distinguished career at the juncture of international politics, public policy, and the environment and has made, continues to make, and will make -- continue to make a very significant contribution. Prior to becoming assistant secretary for policy and international affairs at the Department of Energy, he had been -- and then at Brookings before that -- he'd been assistant secretary of state for oceans, environment, and science. He was also senior director for environmental affairs at the National Security Council in the White House. A number of other positions and has also written some very significant books on the issues most recently about the energy transition through we are now living.

So, I think our plan, David, is first for you to speak for about

20 minutes or so and set out parameters for what you're focusing on and what you're concerned about, and then we will turn that into a discussion for the rest of the time.

So, please join me in welcoming David Sandalow. (Applause)

MR. SANDALOW: Thanks, Dan. It is a great honor to be introduced by Dan Yergin. For anyone who's ever written a book on energy, Dan, you are the gold standard, the guiding light, the North Star.

MR. YERGIN: Thank you.

MR. SANDALOW: So, Dan actually taught -- he taught me a lot before I ever met him and even more since. So, it's great to -- and an honor to be introduced by you and it's particularly an honor to come back and be hosted by my former boss in two different locations, Strobe Talbott.

For anybody who's ever written a book on any topic, Strobe Talbott is all those things. Your breadth is unbelievable, Strobe, from arms control to global governance to now to climate change. And this may be -- for those who haven't read it -- not only is this I think one of the best tick-tocks of the climate negotiations in the past decade, it is also the only climate book I know of that quotes Plutarch, Immanuel Kant, Hannah Arendt, Adam Smith, and Mark Twain. So, I highly commend *Fast Forward* to all of you.

This is the Ho-ping Hotel in Shanghai. I want to start by going back to the summer of 1981, when I was privileged to be an exchange student in Shanghai. I was one of the first groups of exchange students to go to China from the United States after normalization of relations between our two countries.

During that summer, there was one telephone line in the entire city of Shanghai that we could use to call home. One. And we would take cabs down to

the Ho-ping Hotel every weekend to do that. Now, I have been to Beijing six times in the year that I've been in this job, and every time I have the same ritual, which those of you who travel to Beijing from this city probably share. It's a 14-hour non-stop flight, absolutely no BlackBerry coverage during the time that you're, you know, up in the air. As soon as I hit the tarmac in China, I pull out my BlackBerry, I see the 50 messages that have come in. By the time I get to the, you know, to the gate, I've already sent back three messages around the world. In the terminal I've already made three calls, right? Now, if you had told me back in the summer of 1981 that someday I would be landing at Beijing Airport, I would pull something out of my pocket, you know, that was tiny, call around the world by the time got to the airport gate, there's not a chance in the world that I would have believed you. Or there's an old telephone. If you told me that this is what this -- the skyline to the city of Shanghai would look like, I wouldn't have believed it either.

So, you know, working in these energy and climate areas can be - can sometimes take leaps of optimism. I think they're absolutely justified. If we get the best minds around the world, if we get the best -- if we get real resources devoted to solving these challenges, I think we can do it, and that's what I want to talk about today.

I thought I would just in a few minutes talk about, first, some things we're doing domestically at the Department of Energy to help solve these problems, some things we're doing bilaterally, some things we're doing multilaterally, then a quick note about some new analysis and research we have underway, and then a conversation with all of you.

So, it's really fun to work in the Department of Energy these days. I have to say that one reason it is a lot of fun is our boss, Steve Chu, who people

here will know won the 1997 Novel Prize in physics. He is a transformational leader at DOE. I've worked other places in the federal government. As Dan said, I've never worked at DOE before, and I sit in these budget meetings and I wonder what was it like before the Secretary knew more about the topics he's being briefed on than the people who are briefing him. He's also -- he's a very good manager.

And we have had this -- what is an extraordinary opportunity, which is to invest $40 billion of funding. It's under Department of Energy Management under the Recovery Act for Clean Energy. And we have invested in a variety of different airs. We're in the process of investing in home weatherization. Extraordinary opportunity there, by the way.

There are enormous numbers of low-income homes in this country that waste huge amounts of energy by investing small amounts of money in each home. We can improve the energy efficiency, save people money, improve comfort, and create jobs. It's a quadruple win. We've been greening federal buildings. Significant expansion for renewable energy tax credits.

A lot of work on plug-ins. This is incredibly promising technology. General Motors and Nissan are both coming out with the first commercial model plug-ins for mass distribution in the United States this fall. We've working to build up an American plug-in vehicle industry: high-speed rail, carbon capture and storage. United States, China, Russia, India have vast amounts of coal. Unless we find ways to burn that coal cleanly, we are not going to solve the global warming problem. We've investing in bringing down the cost of carbon capture and storage.

We have 5,000 clean energy projects around the country at this point, across a range of areas. This is not mainly what I came here to talk about, but it is obviously mainly what the Recovery Act is all about. On the Y-axis the one-month

job change in the United States. You can see running right up until the signing of the Recovery Act, the hemorrhaging of jobs in this country throughout 2008, the turnaround after the Recovery Act, and the build back up. We obviously have an enormous ways to go to put Americans back to work, but we are moving strongly in the right direction.

This is what I mainly came here about -- came here to talk about, which -- and this is a bit of a complicated chart, but just across the top there you see different stages in the energy investment chain from basic R&D, advanced R&D, to pilot, pilot to demo, commercial, and then down the side you see different categories of investments. the circles represent the amount of funding that we put it in the at year in each of these categories across this grid, and you see because of the Recovery Act investment we're heavily invested in the pre-commercial or just about commercial stages of the chain. But we're invested everywhere as well. Trying to create energy revolution for the United States and the world and talk a little bit about that.

We're doubling renewables with a 30 percent tax credit and loan guarantees. Transforming transportation, this has been a big area. I mentioned this briefly before, but this administration has just in the past year taken without any close competition the most historic steps ever to transform the transportation industry with agreement between major stakeholders and automotive fuel efficiency, the Cash for Clunkers program, grants for battery manufacturing and electric vehicles, and retooling auto factories.

We're also working to restart the domestic nuclear industry. This is base load low-carbon to no-carbon electricity. Very significant work going into restarting this industry with significant loan guarantees. New power plants. It's a

big, big job creator. And we're working to -- we just put a Blue Ribbon Commission to look at the nuclear waste issue.

So, I want to talk some about DOE's investment in early-stage research, which I think would be transformational. Dan Yergin has said that what's happened in shale gas in the past decade is the biggest innovation in energy in this era, and as many people in this audience will know, U.S. recoverable reserves of shale gas have doubled in just the past several years due to advances in -- mainly in hydraulic fracturing technologies.

So, where did that come from? Along the bottom there you see U.S. Department of Energy research funding during the 1980s and a little bit into the 1990s, which supported early-stage development of this technology. And then we see the slow ramp-up in the production in the graph. I think -- this type of investment in early-stage energy technologies can be transformational. I think one of the challenges from kind of a political standpoint can be that the payoffs, although big, sometimes can be a way, you know, years offs, so I think it is really important to look at the energy transformation that's happening today, trace it back to where it came from. In this case, this huge energy transformation came in significant measure from government funding. And the question at the bottom, could methane hydrates be next? -- we're investing significant funding in methane hydrates technology today.

One of the programs that I think we're most excited about at the Department of Energy is our ARPA-E project. It's modeled after the Defense Advance Research Projects Agency, which DARPA was created after Sputnik. DARPA is widely credited in the work there -- helped to lead to the creation of the internet. Also hugely important innovation such as Teflon came out of DARPA. At

ARPA-E we're trying to do the same type of path-breaking research. Secretary Chu likes to say that with ARPA-E programs we are swinging for the fences. It's like in baseball, when you swing for the fences sometimes you hit homeruns, sometimes you strike out, but you've got to be swinging for the fences in order to get those homeruns, and that's what we're doing at ARPA-E.

Just a few examples of some of the projects that we're funding, and there are now dozens of them. This project is focused on large grid-scale storage of energy. People here will know one of the challenges with renewable energy in particular with solar and wind is that the sources are intermittent. Sun doesn't always shine. Wind doesn't always blow. In order to really scale up those sources, we're going to need massive cheap energy storage, which we don't now have. So, this is work in to that.

The basic insight of this process, which comes out of some MIT researchers, essentially in rough approximation putting an aluminum plant in reverse. Aluminum plants take massive amounts of electricity to convert different metal and metal ions into aluminum, and the idea here is to have electricity used to convert dissolved metal salts and then to be able discharge when you're in discharge mode and draw the electricity out. In a kind of rough parallel is putting an aluminum plant in reverse. Not yet proving a commercial scale, but we've got work underway to do it. If this type of thing works, we would have literally swimming pool-size batteries, industrial-size batteries that could be transformational for renewable energy.

Also doing work on carbon capture and storage. Within the body there are enzymes that capture carbon dioxide. We have researchers with expertise in this area looking at whether there's learning from biological mimicking

within those enzymes that could be used for CCS technologies to dramatically lower the cost of capture of carbon dioxide out of flu streams.

And similar work in -- or somewhat similar work for transforming cellulosic biofuels into usable forms of liquid fuels. You know, termites have learned how to do that. I figure human being may be able to learn how to do that, too.

So, that's a brief talk about what we're doing about -- doing domestically at the Department of Energy in researching and technology. Let me just talk some about our bilateral work and then our multilateral work -- and a bilateral work focus on China.

So, I was -- last September, I was on the eight-lane highway between Beijing and Tianjin going -- we were driving like 60 miles an hour -- huge road -- when the Bullet Train came by. It was very cool. It was, you know, going, like, 220 miles an hour in the relative of speed, like 140 miles. I was just -- one moment it's here and the next moment it's gone out in the distance. As we did this, it occurred to me, there's a metaphor here. I mean, I think the United States, all these programs that we have we're getting up to speed, we're making progress in our clean energy work, but the Chinese are investing heavily -- heavily -- in this technology -- in these technology spaces, as are other countries around the world. And I think we all need to work together in order to get the benefits of all this work that all our countries are doing. So, this has been a major priority of ours over the course of the past year.

One project which we're particularly excited about is -- we're in the process of standing up is -- the U.S.-China Clean Energy Research Center. It's a $150 million project, funding split evenly between our two countries, focusing first

on building energy efficiency, CCS in clean vehicles. We actually have an active funding opportunity announcement out there right now. It closes at the end of this week. And we are going to China next week, actually, with this on the agenda in part to talk about standing this up.

We have a range of projects in a variety of areas. These were all announced by President Obama and President Hu Jintao at the summit in November in Beijing, but we have electric vehicles initiative. We had the first-ever U.S.-China electric vehicles forum last fall in China. Tremendous discussion actually, a day and a half of very engaged technical discussions among the experts. A lot of agreement that if we can get together on battery standards, some other common standards, we can really make a difference in shaping global markets. A lot of work on energy efficiency, renewable energy. Shale gas I think is one of the most exciting areas here. The Chinese resource in shale gas is much less well characterized than the U.S. resource. We're working together here. A lot of commercial opportunities for U.S. companies in this area. A lot of work on coal and also on greenhouse gas data collection as well.

So, that's just a word about our bilateral work. I can talk more about that. Let me say a word about our multilateral work. On July 19th and 20th, Secretary Chu is going to be hosting the first-ever clean energy ministerial. We have -- the goal here is simple and straightforward, and the goal is to make concrete progress in advancing clean energy technologies. We're not interested in talk. We're not going to negotiate a communiqué. What we're doing is inviting groups of countries, groups as small as two, as large as everybody who's at the meeting, to come forward and make specific progress on a range of different clean energy technologies.

An electrical foundation for this grows out of the work last year at the Major Economies Forum, which had a process called the Global Partnership Technology Action Plan. It's a great resource, actually, for anybody interested in this. So, we've invited these countries; getting terrific response, a lot of acceptances.

We are also creating a track 2 process. We would be thrilled if the private sector of civil society would participate. We see this as a real opportunity to advance clean energy technology across a range of areas, and let me just talk about one of them, and that's in energy efficient appliances.

This chart shows refrigerators and refrigerator standards. On the left you see the energy per unit, the average energy per unit, and on the right you see -- on the bottom you see years, and so the red is the -- the red line, excuse me, is the volume of refrigerators from 1947 up to -- and this may reflect also the waist lines of Americans, I'm not sure, but you see these are U.S. refrigerators, you know, going up in volume, but at the same time, you see the average efficiency and the average cost of those refrigerators dropping dramatically, and that's because of dramatic advances and the energy efficiency of chillers and other parts of refrigerator technology, and advanced by standards initially in the state of California and then spread globally.

And there is a lot of good work that's been done on international coordination of appliance energy efficiency standards and labeling programs and incentives. In the United States, the energy saved just from refrigerators from these standards saves as much carbon as the renewable energy that we have deployed in the grid today, just from refrigerators. So the energy saving potential here is enormous. We think we can -- we hope we can really shape markets in this. And

this is the type of discussion that we hope to have in the Clean Energy Ministerial on issues like appliance energy efficiency standards, smart grid, CCF related set of topics. We hope this will be a real contribution to helping move the world towards clean energy.

So let me close this by talking about some analysis that we have underway at DOE right now, it's kind of interesting, it's on a set of issues that economists might call positive spillovers, or we've also used the phrase international carbon multiplier. Both of those are pretty wonky, and my favorite phrase is just the U.S. leadership effect.

The question that we're asking here is, if the U.S. acts strongly to reduce emissions and promote technologies, what benefits does it have around the world? So for many years commentators have said that the U.S. leadership is important in fighting global warming, that we're the world's largest economy, we have extraordinary innovative capacities, if we get moving, others will, too.

And so there are at least two broad reasons I think that's probably true, from my observation of this area, one of them is really a political leadership effect, that is, you know, if we act, I think other countries will do so, as well. The EU has been the most explicit about this. The EU, you know, has said that if other -- that they were 20 percent, and if other countries act, they're 30 percent.

But a number of other countries around the world, although less explicit, I think have the same calculation in mind. Now, one way of thinking about this is, that means that every time that we reduce the United States, it'll be multiplied by other times reduced abroad. And so when you see these part-time calculations of what it costs to reduce emissions in the United States, multiply that by some factor, because we're going to generate emission -- additional emission

reductions abroad every time we do that.

But I think there's not just a political leadership effect, there is also a technological effect, and that's what we've been looking at most closely at DOE. And it wouldn't be right to close without some more -- one or two more wonky graphs. So on the left here, you have expenditures in euros actually, this was produced in Europe, and on the right you have volume, you have cost, excuse me, on the Y access you have cost in cap X, and on the right you have volume, and across solar PV, solar CSP -- solar power and CCS, the basic points these charts are making is that as production volumes increase, costs come down.

And so as the United States is the world's largest market increases its demand for these clean energy technologies, we can expect across a range of them that the cost will come down, and that will have -- that will speed deployment not just in the United States, but around the world. So it's another positive spillover, it's a carbon multiplier, or I like to call it the U.S. leadership effect.

And so we're looking at how can we quantify the U.S. leadership effect, which technologies does it supply most to, talking with folks about the political aspects of this, as well. I think -- I mainly mention it today because I think it's a great form of experts and I wanted to start a dialogue on this topic. How big is the U.S. leadership effect, how can we enhance the U.S. leadership effect, and what do we need to do to make it real? So I guess it was 29 years ago that I was in Shanghai. I think the interesting question is, 29 years from now, what will the world look like? I've got teenage kids right now, I'm convinced that some day that they're going to -- my grandkids will look at them and say, what, you couldn't plug in cars when you were young, that's so weird.

I think the answer to the question, what will the world look like, is up

to us. With all the talent in this room, all the talent that's being invested in the clean energy area, with all the resources that's going into it, I believe we can change the world. Thank you very much.

MR. YERGIN: Thank you very much, David. In terms of changing the world and plug-in cars, it does remind me that those of us who even have grown up children now, many of them have never typed on a typewriter, so your point is well taken about plug-in cars.

David, if you take this audience as a large focus group, I'm quite confident that, given the choice between positive spillover, spill being a term not very positive these days, international carbon multiplier, that sounds like increasing carbon, and U.S. leadership effect, I think this audience overwhelmingly favors U.S. leadership effect. Everybody who agrees, please clap. Okay, there's your answer. I'm mindful of the time, so let me just start quickly. There's been a lot of discussion, and so I'll try and be quick in my questions and quick in your answers. A lot of discussion already about Copenhagen this morning. Half a year later, just what's your takeaway?

MR. SANDALOW: I was deeply involved in the multilateral climate negotiations when I was in government in the '90s. In this tour I actually -- I have not been very deeply involved in those negotiations, except that I was in Copenhagen for two weeks. Todd asked me to come and help how I could, and it was an extraordinary experience in many ways. I'm sure other people have already talked about the challenge of the Copenhagen Conference.

The last 24 hours of that conference, I have to say, were just a remarkable experience. We sat in this small room, and sitting around the table was, you know, Angela Merkel and Sarkozy and you know, Gordon Brown, and

Calderon of Mexico, and Ban Ki-moon and Meles Zenawi of Ethiopia. It was a remarkable gathering of heads of state, and there were 113 heads of state who came to that meeting.

And so I think the under emphasized story from Copenhagen is the enormous political attention of this issue that's reflected in the fact that 113 heads of state came to that conference. And there are obviously challenges with the whole consensus based decision-making process in the U.N., which -- but I think the U.N. is an essential forum that we, you know, it has a critical role in the solution of this problem. But I guess my main -- is the contrast between sitting in that room and the experience I had of the White House staff in the mid-'90s, and the NSC staff working on these issues.

And one of my main jobs at the time was to go to the senior directors of the regional office of the NSC, who mainly they were among the most accomplished foreign policy professionals our country had, I know I'm not giving you a short answer, I apologize for that, but I would say to them, we need to put climate change in the talking points for this meeting when, you know, so and so comes to talk to the president, and they would look at me like I was nuts.

And it wasn't a top two issue at the time. And eventually I think they figured out the President wanted to talk about climate change, and so they did it, but the change from that period until now is remarkable. And so climate change is really a top two issue in bilateral relationships, and I think that's my main observation in coming out of the Copenhagen Conference.

MR. YERGIN: Around that same time, of course, we started to see a kind of chipping away or there seemed to be a chipping away at the consensus around the science in climate change. How do you read that today and what's your

message on that?

MR. SANDALOW: Look, I'm not a scientist, but I will say that I think the -- I don't know if I would call it -- I would not call it a chipping away at the consensus of science. I think there have been attacks on the IPCT process. There were a few minor errors in that process. The consensus view that I've seen from the scientific community is that the conclusions of the IPCT are absolutely valid, and there are some minor changes in procedure to be undertaken going forward.

But, look, I mean the vast scientific consensus is that we are in a very scary situation when it comes to climate change and we need to address it. There are tremendous opportunities I believe for our economy in doing so, but we need to address it.

MR. YERGIN: As you said, you've been to China six times in 12 months in a desperate effort to increase your frequent flyer miles, which you're succeeding that. A couple of questions about China. One is that we often hear it said China is going to get ahead of us on renewable energy technology, you talked about the cooperative facility that's been set up; what are we worried that they're going to get ahead of us on? We know that they can manufacture turbans more cheaply because they can manufacture everything more cheaply. What is it -- are we worried that they're going to get ahead of us or are we really the source of the intellectual content?

MR. SANDALOW: Look, there's -- yes, first, by the way, on the flights, United suspended the non-stop flight between Washington and Beijing for four or five months, which was a major reduction in the quality of my life, but they've now restored it, which is terrific.

But on the -- the Chinese are absolutely racing ahead in a variety of

different areas. And they are investing very, very heavily in plug-in electric vehicles. They are obviously dominant players in world solar markets. They are a huge market for wind. They have the world leading long-distance transmission lines. They've got 1,000 kilovolt long-distance, you know, transmission lines, which they're stringing across, you know, from the West to the East, and the United States is 765, I guess. So they're major and dominant players, and I think for U.S. business to be competitive in this space, we need to be investing heavily and supporting that, and that's exactly what we're doing under the Recovery Act. And I think there is a balance of cooperation and competition there. I strongly believe that working together with the Chinese government, we can do more than acting alone, we can, for example, work on common standards to speed the deployment of clean energy technologies, we can cooperate in some research areas where it makes sense to do so, pooling our knowledge. At the same time, our businesses are going to be competing in the global marketplace.

MR. YERGIN: When you're going on these six trips, what do you talk to the Chinese about, mainly technology?

MR. SANDALOW: Yes, we have talked about energy efficiency, renewable energy, electric vehicles, technology in all these areas, as well as market access for U.S. businesses. And I have to say it's been, for example, the first -- first when Secretary Chu went on to China last July, he did jointly with Secretary -- Commerce Secretary Lock, with a combined theme of technology cooperation and market access for U.S. businesses.

MR. YERGIN: I mean, China is both an oil producer, its oil production is actually going up, but tell us what you see happening with electric battery automobiles there, specifically your sense of dynamism there.

MR. SANDALOW: I was -- actually, on the trip to Tianjin that I talked about, where the high-speed rail -- the -- train came by, I was on the way to see a new lithium ion battery manufacturing facility, a company called Li Sheng , an enormous new facility which they are creating -- manufacturing batteries substantially for automotive market. BYD, a leading Chinese lithium ion battery manufacturer, has bought manufacturing capacity, I think sold 400,000 cars last year, planning to diversify into electric vehicles, and is coming out with an electric vehicle model.

The Chinese have 20 electric vehicle cities that they're investing in with new infrastructure. They're investing in a big way in this. And, look, it's a very good thing to diversify China's transportation fuel mix away from simply a reliance on oil to electricity, as well. The energy security benefits for the world as a whole from China doing that are very significant. So I think it's an area that we want to promote. At the same time, we want to be sure that we are investing in our own domestic capacity here so that we're creating American jobs in this industry at the same time.

MR. YERGIN: Do you think it's an area where we might wake up in two or three years and find a surprise we're still back in the Ho-ping Hotel and they're --

MR. SANDALOW: Look, not if we get ahead of the curve, and not if we continue the investments we're making, and we really have smart policy in this area.

MR. YERGIN: Let me ask you two DOE questions. The first one is, it's now a year that you've been in DOE, what's it been like? And secondly, specifically you talked about the Recovery Act and so forth, this is a much more

expanded effort for the Department of Energy in energy R&D deployment commercialization, what have we learned about that so far?

MR. SANDALOW: First, it's really fun working at DOE, I have to say, and I would think the main reason may be what I talked about in my speech, which is Steve Chu - he's terrific, he's fun to work for. In addition to being brilliant and a good manager, he's also -- he's actually a very nice guy and really terrific to spend time with. And he's put together a team that is really first rate, and I'm really -- great to spend time with him. And this -- the opportunity to invest these funds is -- it's a big one, it's a -- it's quite -- the stewardship of these funds is an enormous responsibility and opportunity.

Secretary Chu brought from the beginning a very skilled manager, one of the heads of Mackenzie's Energy Practices, to run the implementation of the Recovery Act, Matt Rogers, who's -- Matt has put together just an incredible effort to play these funds with transparency accountability, hitting our job creation targets and our energy innovation and transformation targets, so it's -- it's been a big push and it continues. I mean it's very much in the swing right now, and it's going to continue, as well, as we have the kind of -- if we have the follow through parts of this. My only -- the only thing I will say I don't like about DOE is the Forestville building.

MR. YERGIN: Why?

MR. SANDALOW: I probably said too much already.

MR. YERGIN: Okay. It's functional?

MR. SANDALOW: It's functional.

MR. YERGIN: Okay, it's functional, it's definitely functional. The spill, it's actually the leak in the Gulf of Mexico. Obviously, authority is divided among

number of different departments, from Interior, Coast Guard, and DOE; what do you -- tell us about what you see is the effect and some of the consequences.

MR. SANDALOW: It's obviously a terrible tragedy. And job one is stopping the leak, and that's where federal resources are mainly devoted at this time. Secretary Chu has been down to Houston, was down there last week, I think literally rolling up his sleeves to help in this effort, has helped to put together a team of experts from the National Labs.

There is a wide range in scientific expertise across -- of course, in our -- in the DOE National Lab system, and one of the questions that's been put out is whether people with expertise not directly in, you know, oil production exploration, but in other areas might have ideas or be able to contribute.

Actually, Secretary Chu personally, as well as others, have already brought to the response some work on gamma radiology and using gamma radiology to image inside the pipes, which I understand is a contribution to the problem, solving the problem. You know, there's a lot more that needs to be done, but it's a very -- obviously a very serious situation. Interior Department is obviously, you know, is in the lead and is taking, you know, along with the Coast Guard, taking very serious steps in this area.

MR. YERGIN: You talked about Shell gas and showing that investment in this decade may not have an effect for a decade and a half. Now we have this tremendous resource, the numbers keep going up, the Canadians have just come out with extraordinary numbers, as well. How does the arrival of gas in this scale and at this price range change the energy discussion, is it still early days -- how does it fit into what's happening with climate?

MR. SANDALOW: I think it's still early days, but it's potentially

transformational. I think we could see natural gas used for electricity generation and significantly higher percentages than it is right now in the U.S. mix. Depending on how this plays out, one can imagine scenarios in vehicle penetration, as well, though I think most of it will be used in electricity generation.

It obviously has significant implications on the energy security front. Before the advent of this technology in the past couple of years, the projections were for steadily increasing imports of natural gas to the United States. Now I think the projections are in the opposite direction, so I think it's potentially very significant, and not just in the United States. As I mentioned briefly in my remarks, in China, in Eastern Europe, in other parts of the world, as well, it's potentially transformational for energy security calculations.

MR. YERGIN: You've spent a lot of time before you were in the department looking at transportation issues, focus on electric car. With the drive to batteries and electric cars, obviously some people say with all this gas, we should be pushing gas more directly into transportation. Do you think that the momentum towards electric vehicles and the focus on that is so strong that this is not a focus or do you see --

MR. SANDALOW: Well, I very much support increased use of natural gas in vehicles. I think it's definitely got utility in some applications. I think -- the -- in the transportation area right now is that 96 percent of the fuel in our transportation fleet comes from this one product, petroleum, about which you know something, Dan. And, I mean, it actually -- it doesn't seem odd to us that 96 percent of the energy in our transport sector comes as one fuel, because we've grown up with that, our parents grew up with that, our grandparents grew up with that.

MR. YERGIN: Sort of --

MR. SANDALOW: Yeah, but it is actually in, you know, many respects extremely unusual to have this one function so utterly dependent upon one fuel, and that has huge implications geopolitically, environmentally, economically, and so I think a core challenge here is diversifying the fuel mix in our transportation fleet, that includes natural gas.

I think my own guess or projection would be that batteries are the more transformational technology, and, you know, electric vehicles I think will be a very, very big force over the course of the next couple of decades where we should be doing natural gas.

You know, by the way, also biofuels potentially play a very significant role here.

MR. YERGIN: I know our time is getting short, so let me ask you two last questions. One is, part of development of electric cars also means changes in the grid and electric supply system, a lot of different definitions of what is a smart grid. How do you see the timing of that, and is that moving at the speed you would have expected?

MR. SANDALOW: Well, I think there's a lot of movement forward on smart grid. It's been a big piece of our Recovery Act investments. There's actually a lot of work internationally on this. I mean it's astounding actually how dumb of a grid we have today. I mean, you know, a lot of people have said this is -- I've heard a number of speeches on this topic, you know, if Edison came back today, he would recognize the grid.

And I heard a utility executive say recently, you know, the only way that we know when our customers aren't getting electricity from our plants is that they pick

up the telephone and call us, and that's actually pretty antiquated technology given what we have today, so, you know, there's tremendous potential.

And just one other thing on that, too, so in this -- okay, we're obviously a bunch of self-selected energy experts -- energy and climate experts. How many people here know how much it costs them to run their refrigerator a year?

MR. YERGIN: One, two.

MR. SANDALOW: It's actually astounding. And we lack -- and how many people in here know within, you know, 25 cents, how much gasoline is selling for on the streets of Washington today? Probably -- I mean, the difference between this is amazing. We are highly, you know, attuned to one and absolutely unclear on what it cost -- I think that's going to change over the next several years.

MR. YERGIN: David, one last question to really be the bridge into the next panel. Clean energy, a lot of your talk is on clean energy. What's in clean energy? Is nuclear clean energy?

MR. SANDALOW: Yes.

MR. YERGIN: Shell Gas clean energy?

MR. SANDALOW: It can be. I mean, I think -- look, nuclear is a key part of our energy future here. It's low or no carbon. It's expensive today, but it can play a key role. Shell Gas is obviously for, you know, half this -- two emissions of coal for the same unit of energy, it's got, you know, zero conventional pollutants, you know. Well, not zero conventional pollutants, but zero pollutants in some categories, and much lower. So Shell Gas has the potential, you know, a very important role in the clean energy future.

MR. YERGIN: We have the next panel come in, a terrific panel with

Shirley Jackson. I'm going to turn it back to Bill Antholis, I believe, and so -- or Strobe, I'm not sure who, but please, everybody, join me in thanking David for his remarks today and for the terrific contribution he's making. Thank you. (Applause)

MR. TALBOTT: Since Dan is a trustee, I ask his advice, I said can we give these folks a chance to get a cup of coffee, he said, no, make them work, go straight into the next panel. Why don't you folks all come on up?

I'm very grateful to have three colleagues from Brookings and also Jonathan who's joined us from the Congress. And while they're getting lavaliered, and so we can economize on time and move quickly along here, I just wanted to say a word or two of introduction about Shirley Jackson. And I'm going to exploit, Shirley, you better watch out because I'm confessing what I'm about to do.

I'm going to exploit her background and expertise to make a point that has come up during the course of the morning, but I just want to make absolutely sure that it's front and center or at least at the base of our thinking about this whole issue. Shirley, as you all know, has multiple credentials to be leading this panel, and, indeed, to be doing many other things. She is deeply involved in the Council Competitiveness's Commission on Energy Security and Sustainability, which, of course, is right in the center of what we're talking about. She serves on the President's Council of Advisors on Science and Technology, PCAST, and no small measure because of her background as the head of the Nuclear Regulatory Commission.

But what I want to particularly underscore with an ulterior motive is that Shirley is an educator, which means that it is part of her current profession to think and work in a way that takes account of the fate of future generations. And that is a point that sometimes slips into the background or seems a little too

abstract to have much meaning in the world of today, when we're worried about today's gas prices, who's going to vote for whom in November, who's going to be able to keep his job in the Congress after November and things like that.

But taking a longer view is a pretty essential part of being responsible, both individually and as a community on the issue of climate change. It strikes me that, as you think back over 10- or 12,000 years of human history, every generation has always felt a degree of responsibility for its progeny. That comes with human nature, it's one reason that we have survived as long as we have. But there have only been two cases in all of human history where the generation in charge had more than just a responsibility for the next generation, but had an existential responsibility for the next generation.

The first, of course, was during the Cold War, when, if we had had stupid leadership as opposed to wise leadership, we could have blown up the planet and incinerated much of humanity. By the way, a possibility that's still available to us, but at least one that we have more or less within bounds. And it happens to be an issue that Shirley knows very, very well in her capacity as an expert on nuclear energy issues.

But the other existential threat is, of course, climate change. And I've been listening carefully to the superb discussion that's been going on, and I've heard elusions to this, including at the tail end of David Sandalow's talk, where he showed that beautiful from the moon or from outer space photograph of our planet and wondered what his grandchildren were going to say, and imagined them saying you mean you people didn't even have plug-in cars back then. Well, I'm worried that we might get a rather tougher message from our grandchildren than just their wonderment at our technological lack of sophistication. I think we're running a very

real risk that our grandchildren could say something closer to, what the hell were you people thinking, and why in God's name did you not get a grip on this problem when you had an opportunity to because now we're in charge and it's too late to do anything about it.

So this is the issue of what I call not just intergenerational responsibility, but transgenerational responsibility in that it isn't just about conserving the legacy that we got from previous generations, it's making sure that there is a legacy for future generations, and I can't imagine anybody better to open a discussion including on that point than somebody who is responsible for educating the next generation.

So, Shirley, over to you.

DR. JACKSON: Thank you. I'm also educating the next generation of those who will help to solve the issues. You know, events in the Gulf of Mexico and here in Washington over the last few weeks have shifted the dates and alliances in ways that we could not have imagined. But tackling the linked, and they are linked, vulnerabilities of energy security and climate change remains one of our top priorities at both the international level, as you have heard through discussions this morning, and at the domestic level, which we're about to discuss in more depth. In fact, as Strobe has clearly stated, it is a key priority because it is the key challenge in my mind of our time and a fundamental intergenerational responsibility that I not only agree with, but understand as a university president.

But how does the United States actually construct a comprehensive and consistent framework that takes into account the policy, regulation, infrastructure, markets, research, technological innovation, and human capital needed to transform our energy system?

In other words, how are the linked challenges of energy security and climate change policy to be articulated in a way that can lead to movement, articulated to the public and to legislature?

Now, I have suggested that our nation needs a comprehensive energy security and climate change roadmap guided by five key principals, the first, which we've had some discussion about, redundancy of supply and diversity of source, to provide protection against the supply disruption events, such as accidents, natural disasters, or geopolitical instability, and to provide a hedge against price volatility, and this includes the use of what are called bridge technologies that include things like natural gas, nuclear energy and what people refer to as cleaner coal. A second principal involves, of course, a focus on energy conservation, efficiency and environmental sustainability, and this includes the development of new technologies, but with calculations of full life cycle costs of both policies themselves and product.

A third is linking optimum source to sector of use, thinking strategically about how each sector uses energy and intersects with other sectors. Now, the Kerry Lieberman bill tries, in fact, to do this, as one looks across from utilities to manufacturing to transportation, but one aspect of transportation that we never talk about very much is airline transportation.

The fourth key principal involves, of course, investment in sound infrastructure for energy, generation, transmission and distribution, and that includes, of course, the smart grid, but it includes fundamentally a stronger grid, but it also includes methodologies for extracting or developing other types of energy sources and how we get them to where they're used. And the fifth key principal, of course, is having well functioning energy markets with transparent price and pricing

signals and safeguards against market manipulation. And one needs to think about that as one looks at carbon allowances trading, looking at setting fees on carbon content, et cetera.

But given the fluctuations in public and political opinions, the volatility of world markets and the tasks that were left on the table at Copenhagen, some may be looking today for a less comprehensive plan of action. But unfortunately, a less comprehensive plan may prove incoherent and ultimately ineffective and doesn't look at the intersecting vulnerability.

So how do we get around this? Are there points of consensus and how do we build upon them? How do we educate the public? What are technological challenges and how can we overcome them?

You've heard some about what is going on in the Department of Energy and David Sandalow's very compelling presentation, but what is the right sustainable framework for linking research, basic research to user need research to translational pathways for the creation use and commercialization of new energy technology? If we're going to have leadership globally, we have to get this together. And so fundamentally, how are we going to go from rhetoric to reality? What is realistically possible, and what time frame, and in what sectors, and what sectors first? And if we are successful in passing climate change legislation, money will be generated from user fees; what will the money be used for, what should it be used for?

So to help us to begin to address some of these questions, we have a distinguished panel of experts and let me now introduce them. We have substituting for Robert Simon, who's in your program, who is the Staff Director of the Committee on Energy and Natural Resources in the United States, is his

colleague on the Committee, Dr. Jonathan Epstein.

And, Dr. Epstein, thank you for being here. Dr. Epstein is an authority on energy research and development, working closely with Committee Chairman Senator Jeff Bingaman on national defense, energy R&D and global competitiveness.

And Dr. Epstein, and each one will speak in turn with brief remarks, and then we'll have a brief moderated discussion, but we would like to get your questions and thoughts. Dr. Epstein will provide us insights into the latest discussions in the Senate on where we stand with climate change and energy legislation.

Then we have Dr. Barry Rabe. He's, in fact, closer to me, and he is professor of public policy in the Gerald R. Ford School of Public Policy at the University of Michigan, with appointments, as well, in the School of Natural Resources and in the program in the environment, and he's a non-resident senior fellow in governance studies at Brookings.

Dr. Rabe will discuss some very interesting and very late breaking polling work on U.S. citizens' attitudes toward an appetite for government action to address the challenges of climate change. And in light of one of the earlier questions from the audience, this is an important work.

Mark Muro is next to Dr. Epstein, and he is a fellow and director of policy for the Brookings Institution's Metropolitan Policy Program. And he is research director of the Brookings Mountain West Initiative. He will discuss the need for innovation and financial support if the U.S. is going to transform our energy system.

And finally we have Dr. Charles Ebinger, who is the director of the Energy Security Initiative at the Brookings Institution. He's had very extensive

energy experience as an energy consultant across the world. He has a strong policy and foreign policy background. In fact, he helped to establish the International Energy Agency and its oil sharing mechanism. And Dr. Ebinger will focus on the short and mid term steps in energy system transformation. In particular, he will discuss the bridging technologies our nation needs as we transition from fossil fuel dependency.

Now, each panelist has been asked to talk for about 5, and I think they were given up to 10, but as the moderator, I'm going to ask them to 5 minutes of comments so that we can then have a discussion. And we only have one hour for this total discussion with four very dynamic individuals with important messages, so let us begin.

Dr. Epstein.

DR. EPSTEIN: Well, thank you. It's very rare when I get out of my rabbit hole called the U.S. Senate. It's usually Bob Simon's job. But I think it's also evident that -- why I'm here. If you look at the energy dynamic in the Senate, I will basically speak to the Senate. When I listen to Chairman Bingaman in my meetings with him, and he routinely has many visitors come in, and I sit there and take notes for follow-up, the message he -- they ask him routinely now is, well, what do you think about energy bill prospects and climate bill prospects, and I think the latest coming from the chairman is confused. I hate to use that word, but the events that have transpired since late April have sent a whole new dynamic motion in the Senate, as it should.

If you look at the calendar, what we call the Day Book for the hearings, this week alone I think there must be ten hearings on the deep water horizon. The Energy Committee is having Secretary Salazar and others, but it's not

just the Energy Committee, it's Homeland Security. There's even one in small business, on the effects of small business. And the body as a whole has to grind through the effect of this incident before it can realign itself on the legislation before the Senate.

And to give you an idea of the magnitude of this incident, I was driving to work today after dropping my daughter off at kindergarten, and I was listening to NPR, and you know, it just struck me, and Dr. Jackson will probably appreciate this, but they're putting a commission together, and they use the word the Three Mile Island Commission in magnitude or scope in the same phrase as what happened at the end of April. And so when you see this kind of phraseology being used by the executive branch, and the press picking up on it, and the Senate, of course, and the Congress as a whole, responds accordingly to this, you can see why Chairman Bingaman has used the word a little bit confused right now as to how energy policy will move in the Congress.

Let me just give you where we are before the incident happened. There's S1462, I think which is basically the Energy Committee energy bill. We have a jurisdiction primarily of energy. That bill was reported out in late May/June timeframe last year and has been on the Senate calendar.

I think you all are all familiar with some of the efforts underway to try to develop coherent energy policy and climate policy. It's not necessarily a jurisdiction of the Energy Committee, we do have jurisdiction, but it's multi jurisdictional, and I think you all have heard the Kerry-Lieberman legislation, and I really won't speak to that, per se, because that's still being evaluated by our committee and the other committees of jurisdiction.

But the trick, if you will, then is to merge these two pieces of

legislation together in whatever form and bring them to the Senate floor for debate and consideration, knowing that anything of this magnitude has a 60-vote threshold to cut off debate. And that's all a very steep hill to climb as you move forward. The fact that the legislation that the Kerry-Lieberman proposes is so grand and sweeping means there's a lot to digest by each of the committees and we're in the process of doing that.

I think within the energy bill context, it's been out there for about a year, and within my world, which is innovation and R&D, I think it's -- we have fairly well settled principals of proposing things such as energy hubs, increased, applied funding for energy R&D, increased basic science funding to move forward. That's been examined I think out in the public court now for about a year now, and we've had generally positive results in that area.

So I'm going to stop my comments right about now to just turn it over to my colleagues. But again, there's a lot of dynamic going on right now and it's even a little more turbulent and it'll shake out, it'll take another -- a least a few weeks before we have a clear signal.

DR. JACKSON: Well, that's an important set-up, because, you know, what happens is, things seem to be moving in a certain way, as you're pointing out, through the Congress, and then something happens. On the one week it's immigration reform, but then, of course, this major catastrophic event in the Gulf. But a lot of what drives, obviously, what happens in the Congress has to do with what citizens believe, particularly the electoral public. And so I think, Dr. Rabe, why don't you tell us what you've learned about the public thinking on these issues of climate change and energy and the linkage, how much do they even understand about the linkage, and how much are those attitudes likely to be modified by both

what happened in the Congress as it moves back and forth, but also from specific incidents like the deep water horizon?

DR. RABE: Certainly. Well, it's been a tumultuous couple of years for climate policy discussions, as we've been discussing. It's also been a couple of remarkable years for the way in which Americans come to understand and view this issue. We're all familiar with volatility and surveys and head to head races for political office, but it's relatively rare in longer term survey analysis to see levels of fluctuation as we have in just a matter of a couple of years in basic questions concerning climate change, global warming.

One measure -- and most of my comments here are drawn from a series of telephone surveys that I've been involved with over recent years that are published through the Governance Studies Program at Brookings. One goes to the baseline of November 2008, the presidential election, using a standard question, do you believe that there is solid evidence that the global temperatures have increased over the last four decades, even before we get to human causation. We found 72 percent of Americans respond and said yes, and that's pretty consistent. The most recent survey analysis from a few weeks ago, that has dropped to 52 percent.

In however you turn the prism, and Eileen Claussen raised good questions about methodology and survey issues and survey techniques and the like, we have seen significant changes in the human causation issue, problem severity, do you see signs of climate change in your own locality or home arena across the board.

That said, we've also asked not only what do you think is going on, but why, and what we're finding is that, yes, there has been a huge decline in confidence and the capacity of media to report credibly on this issue. There has

been a stunning decline in the last year in the extent to which Americans believe scientists studying climate are credible sources of information. But to invoke Tip O'Neill, all climate policy understanding or all climate change understanding seems to be local. However we frame the question in survey after survey, American citizens relate their understanding of temperature and climate and climate change most intensively to local experience, what they have seen in weather patterns in relatively recent periods of time, temperature up, down, what were things like a year ago, however you put that survey together. So I think this is clearly a volatile area.

And to go back to a question that was raised in our first panel, how we begin to understand, present, package and present data on this very fundamental issue becomes a significant challenge going ahead.

A second area I just want to touch upon briefly, although we might engage this in other ways, as well, is policy and support for policy initiatives. What we have not seen in these surveys is a commensurate drop in public support for the idea that governments across levels in the United States ought to be doing something to reduce greenhouse gases. Even among people who are seeing less signs or are less persuaded that global temperatures are warming, we have not seen that kind of shift. So when we ask state, federal, local, or state, local, federal, there's not that same tectonic shift, there is, indeed, some movement, but not nearly as significant as one might have expected. And consequently, when we look at our most recent survey analysis, we see a similar kind of triage in terms of response to different policy initiatives, pretty substantially by margins in the 60 to 70 percent level, Americans cutting across most demographic divides, but with a substantial and enduring partisan split, which has been there throughout survey analysis on this issue.

Americans strongly like the idea of renewable energy standards or portfolio standards, that tends to come in a track unit about a 70 percent level pretty consistently over time. There's consistently strong support for the policy tool that David Sandalow was talking about before, mandatory vehicle fuel efficiency standards, even in the state of Michigan.

Similar issues for renewable fuel mandates, especially when you move to beyond ethanol and other biofuels, even subsidies in different regulatory activities that would support nuclear power. Where support begins to drop off, as it has all along, is when you move into areas that are more explicitly known as carbon pricing, cap and trade. Try to convey in a one paragraph question what cap and trade is all about for carbon. And we've seen, in fact, our textbook analysis of how if you maneuver a question or a line here or there, you can get a ten to 15 percentage point balance.

The most recent survey analysis that we have when we talk about allocation of permits and explain how cap and trade would work, without talking about optioning or revenue generating capacity, we find a near majority of Americans are supportive of cap and trade, although clearly there's much uncertainty and much volatility depending upon how you shift and frame that question.

Then dropping further in support when you use the T word, taxation, fossil fuel taxation or carbon taxes, although here, interestingly, we consistently see significant differences. Fossil fuel taxes, carbon taxes survey at a higher rate of support consistently over years than gasoline taxes. And then, of course, issues emerge such as how much the tax is going to be or what is the cost going to be of cap and trade.

And here's some work that we've done, and we published this through Brookings, we began in surveys in recent years to ask the same question, how do you feel about cap and trade, how do you feel about carbon tax, but then come back to the same question and put a price tag to it, $15 a month per person using the Waxman-Markey. Remember way back when, when the postage stamp was invoked, a postage stamp a day. You price that out to about $15 a month. When you ask that question of American citizens, support for cap and trade drops, support for carbon tax actually goes up a bit, so they're statistically indistinguishable from one another. Support for both drops as the rate goes up. And clearly there is much, much work and thought that can be done here.

We've also begun to explore issues such as if, in fact, revenue is generated through a tax or a carbon trading mechanism. Much is being done in the 10 northeastern states through the Regional Greenhouse Gas Initiative. How would you like to use or reallocate that revenue? I think there's some interesting elements and pieces in there, as well, but perhaps we can get to that later on.

DR. JACKSON: Okay. Mr. Muro, you're an advocate of innovation and financial support to get us from here to there. And then, of course, Mr. Ebinger is going to tell us what he's going to -- from here to there. What do you mean by innovation in this context?

MR. MURO: Well, and it's a pleasure to be here. You know, I think we've heard a lot of, you know, critical background here in congressional dynamics, carbon dynamics, international forums, public opinion, but, you know, I think we need to focus on what really has been largely neglected, you know, in many of these discussions, clean energy technology, but how we're going to pay for it over the long (inaudible).

Now, I want to make three points. The first point I want to make is, we can't leave energy system innovation, I mean R&D efforts, technology breakthroughs and so on out of the discussions, and they tend to disappear for long periods of time in some of these discussions.

Put simply, we just don't have the technology base we need to be able to reduce carbon emissions by 80 percent by 2050 to keep global warming within acceptable bounds. We can make sizeable gains in the next 10 to 15 years through simple efficiencies and the deployment of basically existing technologies, but beyond that, we simply don't have the basic science, the applied R&D, the demonstration breakthroughs, the refinements, the continuous iteration and process innovation we need to deliver, you know, low-cost deployment and the massive emission cuts the nation and the world are going to need over the next 40 years. I'm worried not so much about the next 10 years, I'm worried about year 30 to 40. And we simply don't have even things that people believe we have.

We need solar panels three times more efficient than the ones we have now, but we don't have them, and that breakthrough is actually farther away than people think.

DR. JACKSON: We do have the material?

MR. MURO: Yeah, the material, yeah.

DR. JACKSON: Okay.

MR. MURO: Transmission lines that don't lose significant portions of their load, and then we need batteries for vehicles ten times better and cheaper than we have, and we're going to need a whole new battery chemistry to do that. So my point here is not that these are not worth shooting for, my point is they're farther away for the cheap massive deployment that we need.

So we need breakthroughs, big, disruptive breakthroughs to change the game, not so much in the next 10 years or 15 years, it's about 30, 40, 50 years from now, we could come up short. Now to my second point, we need to figure out how to pay for such breakthroughs here in Washington because we're going to need public investments to get many of them. The magic of the market will help us immensely if it's properly nudged and shaped, but it won't deliver all the innovations even then we need even with the high carbon price or regulatory interventions. Why? The reason is, we have very significant, widely recognized market failures that impede the private innovation system, and they're inherent. Nobody is doing anything wrong, they're simply structural problems of the market.

Often it's hard for companies to realize the benefits of long range innovative activity because those of public goods. They accrue to groups of companies. They can't be fully monetized for individual companies.

We have tremendous uncertainty and lack of information about relevant market and policy conditions now and going forward, and the kind of turbulence that I think Jonathan has spoken about is probably going to be, in many respects, a standard, you know, steady circumstance of market creation. So we're going to need to recognize that the federal government is going to need to invest aggressively and soon on a large scale, which brings me to the final point. We need revenue for clean energy innovation, and lots of it. By our calculations, we need to be spending 15 to 25 billion a year on federal clean energy R&D just to give us research intense, you know, on par with other innovation driven sectors like IT, health, or even agriculture, which is actually more research intensive than the energy sector.

We're spending about 4- or $5 billion a year now, a significant

improvement on where we've been, but that's one-fifth the level of the early 1980s as a share of GDP. So where is another 10- or 20 billion a year going to come from, you know, in the near to median term? That's the question we need to answer, it's something that bothers Jonathan, I know, and it should bother us all.

We've seen the difficulties that we'll continue to have with the yearly appropriations process, it's not going to get any easier. The funding of just three of Energy Secretary Chu's eight proposed energy innovation hubs last year reflects how tight money is. The kind of scrutiny of every single dollar, that's a very serious problem for the future. But as it happens, comprehensive climate legislation hasn't worked very well either as a revenue source. Here, I mean I think a lot of people, you know, welcomed Waxman-Markey and other comprehensive bills as a welcome vehicle for generating substantial dedicated revenue for clean energy R&D, but despite efforts in that direction, that bill applied only about 2 to 3 percent of the allowance revenue to R&D, per se, and less than 3 billion. Things aren't that much different with Kerry-Lieberman in the Senate, again, at the same level of R&D effort.

And to be fair, there's another 5 or 7 percent of the revenue that will go to deployment efforts around clean energy vehicles, advanced batteries and so on. But even then, massive allowance giveaways, you know, again, severely depressed, but the stream of revenue available for public needs.

So, in short, you know, we have a congressional dynamic that continues to require the legislators give away the store in certain ways simply to get the political support needed to pass the instrument. So we're groping to a vision of, you know, economic transformation through climate response, but we're not there yet, and we're going to need, you know, sooner or later a major dedicated revenue

source for clean energy R&D through some sort of major climate bill, and as of now, I think even -- I'd be interested in hearing what the, you know, survey data is saying about innovation investments, but still in Congress, this is not a top priority, and we keep dishing out revenue to many other purposes, but not sufficiently to this one I think core long-term need.

So we're going to need to get more serious now and ask two questions to each and every piece of climate or energy legislation that comes down the pike, among many other questions, but we need to ask what does it do for clean energy R&D and where is the money going to come from. So I think there's, you know, an important, you know, choice that needs to be -- or an assessment that needs to be made of every vehicle. So when we can obtain better answers to those questions, then I think the nation will be in a better position for the future.

So thank you.

DR. JACKSON: Well, you know, many people deal with the here and now and think about how do we get from here to there, and I'm going to come back with a follow-on question for each one of you that links what you say to each other. But let me hear from you, Dr. Ebinger.

DR. EBINGER: Thank you, Shirley. We just hit the nail on the head with Mark's presentation, and that is the only way we are going to transform our energy situation is by paying higher prices for energy, and until this country wakes up to that fact, I don't think any of the things I'm going to talk about or what you've already heard about are going to occur. Let me just start with electricity grid, because we've heard some mention of that earlier today, and just talk about -- because we all know that in the final analysis, we can start -- we can talk about smart grid until we're blue in the face, and people have different definitions of smart

grid, as we've heard. I generally think of it more at the distribution level to the end use customer, but there are things on the centralized grid that can count a smart grid, too.

But the reality is, we don't have a modern electricity grid, we have a fragmented grid, essentially an east, a west, and a separate one in Texas. It's not a high D.C. current grid that can move power more efficiently and effectively over long distances. To upgrade this grid there have been numerous studies recently done.

DR. EBINGER: The cheapest investment required that I have seen was one done by FERC. And that placed a price of $350 billion over 10 years, a manageable sum if we put some kind of fee on everyone's electricity bill. But, of course, no one wants to do that. But the reality is, until you have that grid, the transition to the world of renewables is not going to occur because our vast wind resources that we have kind of from North Texas up to the Canadian border and a few other places like Wyoming and, of course, some offshore areas, and our vast solar resources in the Southwest, which are far away from major load centers in most cases, need a modern transmission network in order to deliver those resources in the volumes that we believe they could be delivered if we had such a network.

But the problems here aren't just cost and aren't just political will to do this. We have some real institutional problems that we need to address head-on. And again, the Congress, and to some extent the administration, have not really tackled these as head-on as they might. Just contemplate that we're talking about a vastly different array of physical entities that comprise our electricity grid. So we're going to have to get the interests of the investor-owned utilities; of

government utilities, like TVA, Bonneville Power, and so forth. Municipalities often own their utility grids. We've got imports coming fairly substantial from Canada, our neighbor to the north. We've got also merchant plants, meaning someone builds a plant and takes the risk that there will be an end-use market for their electricity. We now have regional transmission organizations. And to top -- on top of everything else, we have about half the states roughly in the country with deregulated power markets and half with regulated power markets and power moving back and forth into these markets. And how you allocate costs can keep lawyers and consultants busy for the next hundred years.

So I'm just saying we've got to take the transmission network and turn it into a modern grid if we're going to deliver not only the renewable resources but our conventional resources in greater volumes as well.

We have heard a lot about, and I'm a strong proponent that natural gas, particular shale gas, is transformative. Dan Yergin made a reference to not only the huge shale gas reserves we have in this country, but -- and our neighbor to the north in a report released last week, probably 60 percent more than we believe we have. But what we need to start realizing is right now every utility, if they think about using more natural gas for power generation or for other uses, makes that decision based on their own network. What I would argue we need is the United States' government and the Canadian government to sit down, look at where these resources are, decide where we can allocate them on a bilateral basis in the cheapest possible manner, what additional transmission lines for the gas need to be made, if indeed they do, and really come up with a North American gas plan. Because otherwise we're going to make some investments that aren't the least cost way of using these gas reserves.

NGVs, natural gas vehicles, offer a tremendous opportunity, but again it's not going to transform our dependence on oil. The best estimates I've seen is if we pushed all out, meaning all vehicle fleets and other gas uses in transportation, that we might replace eight percent of petroleum demand after quite a substantial investment but that is a homegrown energy resource and so probably merits some examination of the relative economics of doing that.

Coming back to transmission for a minute, one point I forgot to mention is again because of our regulatory process, it now takes about 14 years to get a major transmission line sited, approved, environmental assessments, and whatever. So in a sense, unless we streamline this process, we are already living in 2024, 2025 in terms of what we're going to have as a network to develop our bridge renewables.

DR. JACKSON: Thank you. Okay. So now we have the issues clearly delineated. Let me go back to you, Dr. Epstein. And I'm going to have two quick follow-on questions because I'm going to leave time for the audience.

Has Congress in a way boxed itself in? You know, we have PECO . But then there are things that are left outside of PECO, like things having to do with oil -- things like oil depletion allowances. And then there's been kind of an extension of what that means into things that relate more to manufacturing, but yet it gets left outside of the envelope of things that one can consider. We have allowances that are made in order to, of course, garner political support. And then because we have PECO, because there are certain things that are sacrosanct, we end up using revenues that potentially might be generated by whatever the scheme is that ultimately gets enacted, assuming it does, largely being used to plug other holes. And therefore, we don't have the actual revenue base to do what we think.

And perhaps that can cause cynicism on the part of the larger public in terms of what benefit this really becomes to that. Can you speak a little to that?

DR. EPSTEIN: Sure. PECO is an interesting topic, I mean, for those inside the Beltway. Usually around February of every year we have this thing called the budget resolution and PECO, and imminently gets wrapped up in that. But I think in terms of energy and incentives for energy R&D, Senator Bingaman actually gave a nice talk to the President's Council on Science and Technology.

SPEAKER: I know. I just saw it.

DR. EPSTEIN: Yeah. And I actually helped write that speech. But, you know, part of that -- that speech, interestingly enough, you know, usually when you're a speech writer you come up with your own ideas and you shove it under the door and then you go away. On this one he did to PCAST, he actually pulled me back in on the Friday before at about 3 p.m., I think, and had his own outline, which is the most terrifying experience you could have when it's due Monday morning. (Laughter)

The outline was specifically for Senator Bingaman. He sits on the Energy Committee and the Finance Committee. And so it gives him a unique view of the incentives to promote energy as a whole. You know, the Energy Committee, by and large, uses year-to-year appropriations and authorizes them, but the Finance Committee deals in a world of PECO and tax incentives. And there's a -- I think the Environmental Law Institute -- there's a very interesting chart that I would recommend everyone looking at. If you look at the world of total incentives that we as a Congress allocate towards promoting energy -- renewable, nuclear, fossil -- you'll see huge disparities because the fossil energy incentives were enacted before PECO. PECO was due to the Budget Act of 1974, which is a very rational,

easy to explain thing to the taxpayer that if you're going to allocate for it you've got to pay for it from another revenue stream. And that was enacted in '74. Most of the fossil energy tax incentives, as I understand it -- and I'm not the tax person, although I quickly learned about it over tortured phone calls Friday afternoon -- were done before 1974. They're embedded in the law. They just -- they were done before PECO.

If you look at renewables or even some of the nuclear incentives we put in the 2005 Act or maybe some of the transmission incentives, I'm not quite sure, they were done in a world of PECO. And as a result, our window is about 10 years. And even worse, if you look at some of the investment tax credits for wind and things like that, they expire sometimes in two to three year windows. And you can actually look in the renewable world for the wind energy generation. There's a very famous chart. I think AWEA we called them. The Wind Energy Trade Association shows that as the ITC expires you'll see build-up and decrease, build-up and decrease. And that's because of PECO.

So there's an argument I think we need to look at holistically, and Senator Bingaman was the one that came up with that I would say but I think many inside the Congress worry about it, is how do you -- how do you promote a coherent, long-term energy policy when it has to be paid for? And if you look at the tax incentives, in many ways they are many times more than the annual appropriations we do to incentivize.

In the climate world that's equally true. You know, if you look at the two percent for R&D that comes from auction certificates. It's a PECO rule. In other words, if you want to get up to 15- to $25 billion, you're talking numbers in auction certificates well above 10 percent I think. And then that catches people's

attention. So intimately tied up in the policy debate is the PECO argument. It's a sound argument we use but you need to consider it now as you move forward.

DR. JACKSON: Right. And you have to consider what's in and what's out. You know, what's been grandfathered. But given those kinds of constraints, Mr. Muro, let me ask you this question and then I'll come back to you, Dr. Epstein.

You talked about market failures that would suggest the need for federal government intervention. But I know you're involved with the Metropolitan Studies Program, obviously. And what I don't hear a lot about is, are there, in fact, other impact mechanisms that can provide more linkage from the federal to the state level that also involves public-private partnerships. And so while there may be market failures, are there ways to incent or bring together parts of the private sector to make and join in these sorts of investments as well? Do you have some thoughts about that?

MR. MURO: Absolutely.

DR. JACKSON: Please be succinct.

MR. MURO: And partnerships are actually beneficial even as forms of research activity, too. So we should be seeking --

DR. JACKSON: Right. Absolutely.

MR. MUNRO: -- multi --

DR. JACKSON: I haven't, you know, limited what those things --

MR. MUNRO: Right.

DR. JACKSON: -- could be structured to support. But I'm just asking you your perspective about, one, is this one part of a picture; and two, you know, how can they be structured?

MR. MUNRO: I think that's -- it's a critical way to enlarging the investment here and should be thought about even -- we should have, you know, partnership be rewarded in R&D. You know, we're thinking about those sort of -- structuring all of these kinds of linkages. And it's a critical thing, though we still will need -- there is though a strong federal responsibility.

DR. JACKSON: Absolutely. We're not -- that's a given. You know, I'm on your side on that.

MR. MUNRO: Yeah. So, no, absolutely. And we need research combinations between states where -- though they are vulnerable as we've seen with the state local fiscal crisis and, you know, we have promoted the notion of energy discovery innovation research centers or the hub idea, which is, you know, not only to reward and accelerate collaborative research but to get, you know, large companies' dollars at the table. Same with universities. So we need to be thinking institutionally constantly about creating multidisciplinary partnerships, financial and other.

DR. JACKSON: This is kind of a joint question for Drs. Ebinger and Rabe. You know, as you look at this kind of jumble of layering and who has what jurisdiction and who doesn't, you have -- I'm well familiar with the fact that Texas is its own country as far as the grid is concerned because as chairman of the NRC, the Nuclear Regulatory Commission, it turns out that the stability of the grid is important both for nuclear power plants, and nuclear power plants play a key role in stabilizing the great big base load plants, too. But the interoperability of the grid becomes important if there is a breakdown.

So is federal preemption the strategy here? Or will that only exacerbate innovation that is occurring at state levels, although there are some

experiments that seem to be working in states and some not. So, I'd like to hear from both of you in that regard.

DR. RABE: Clearly the -- one of the unexpected developments of the last decade or so is that a policy arena that's been talked about as global warming and global climate change has had so much policy content below the national level, certainly local. But in American parlance at the state and regional level.

And so, you know, as we gather today there are 29 states that have global portfolio standards, 22 or 23 that have made some degree of commitment to carbon cap and trade. And so when you ask the issue of preemption, that's an inevitable question of federal system. And it's an issue that's emerging in Australia, in Canada, in India, where there is some shared governance concerns. It even emerges in some cases in China, which we tend not to think of as a federated republic by any stretch of the imagination.

Within that there are always opportunities for learning best lessons, best practices, distilling from real world experience what may or may not work. I'm not convinced we are on the verge of that. I think preemption has many merits but can often be a blunt instrument. And frankly, opens up the possibility of an incredibly complex set of negotiations. You know, suspend imagination and say that the Senate of the United States has an epiphany tomorrow and passes Carrie Lieberman as written, and the President signs it into law by weekend. There are provisions there that talk about preemption and compensation to states. Every state has a different understanding of what compensation should mean.

DR. JACKSON: Of course.

MR. RABE: And within that you get into some very complex bargaining kinds of issues, especially after a 10-year process where states have

dominated the playing field.

DR. JACKSON: Absolutely. Charlie?

DR. EBINGER: That's a tough one. Because I'm not sure the courts wouldn't get -- ultimately get challenges with federal preemption. But I think on balance that the situation has, both for natural gas pipelines and power lines, that the situation has gotten to the point where we need federal preemption.

DR. JACKSON: That's interesting. There is a kind of preemption that exists in the nuclear arena but you can ask me after the fact.

Let me go back on this question of the commission that's being created, the presidential commission that relates to the incident in the Gulf of Mexico. And you said that terms like comparing it to the Three Mile Island Commission, which had a big effect on my career --

SPEAKER: Oh, yeah.

DR. JACKSON: -- the way we structured the NRC. It raises the question of how well prepared is the government and the Congress to really understand the risk, and, therefore, how it should fold into or not public policy development, especially as it plays out in legislation and in other arenas.

SPEAKER: Well, I'll take a stab very quickly. You know, and again, I have to caveat myself because there are many hearings underway right now and there's only so much information members of Congress can absorb in the area of risk. But informed risk assessment versus the need, there's a balancing act. We need nuclear power but we accept a certain amount of risk. And we promote our regulations accordingly from the NRC in that balance. And I think in many ways people are asking in this latest incident has that risk balance been properly adjusted. And I think there will be many more hearings to uncover that.

But there are some people at the national laboratories saying, look, these are big Department of Energy facilities that deal with nuclear power and in some ways our nuclear surety of the weapons themselves, to apply many of these tools that they've used in some of the latest incident –- the latest incident that's happened from a scientific point of view. So I think that's an ongoing discussion but some people are asking that question in that context.

DR. JACKSON: We only have about five more minutes. Let me take one or two questions from the audience. This gentleman here, and this gentleman here. Please.

MR. WEISS: Yes. Marc Weiss, Global Urban Development. This question is for Jonathan Epstein.

I'm just wondering on the theory that half a loaf is way better than none at all, is it possible that if this year Carrie Lieberman doesn't do too well that the Senate will pass the Energy Bill that you describe, the House will pass that bill, and the President will sign? Is that something that could happen this year?

DR. EPSTEIN: Oh, I think it's way above my pay grade. I think Senator Bingaman has advocated bringing the narrower bill to the floor and in the nature of the Senate offering up amendments. But I think that has to be all resolved at a leadership level with Senator Reid and the chairman of the committee. But I think, you know, I think that's just something that the members have to figure out and respond accordingly. And I understand that they're looking at -- they're supposed to be looking at that after Memorial recess.

DR. JACKSON: Right. Please. This gentleman here.

MR. ALTMAN: Hi, I'm Fred Altman. And my question is for Dr. Rabe.

Is there anything in the survey data that would suggest how we can make our scientific knowledge more acceptable? If we can't sell what is the best information we have, there's nothing else that's going to happen either, I'm afraid.

MR. RABE: It's a fair question. I think there are several issues. One, I have been intrigued again with the state experience by how in a lot of jurisdictions the ability to understand changes in climate really becomes significant and real in the lives of people because you're talking about more localized impacts as opposed to debating a temperature degree up or down.

An example. The only jurisdiction in North America that has an aggressive program to impose a carbon tax is British Columbia. I don't think that would have happened if there hadn't been something called the mountain pine beetle that because of changes in winter temperatures proliferated -- you can gather the rest of the story. And in each part of North America there is a different climate story and issue under play. I'm not saying you salami slice into each unit but that clearly becomes part of the issue and part of the package. I also think there are huge reorganizational issues, and now as we're looking at the possible reorganization in the Department of Commerce to create a climate service or a National Climate Service, it's a very interesting moment to think about the confluence of disciplines that need to be at this for the long haul.

DR. JACKSON: Before we thank the panel -- and we should because it's a very distinguished group and I would encourage you to grab one of these folks if they can stay for lunch -- I think a question -- I raised the question about Congress and risk assessment. But to what extent should the oil and gas industry itself, as a matter of regulatory oversight, legislation, whatever, be required to do more robust disaster scenario planning and risk assessment and then to

develop industry comprehensive and transparent disaster mitigation plans coming out of that?

Should that occur, Dr. Epstein?

DR. EPSTEIN: Well, I think people, again, that's for the elected officials to decide, but I think for those of us that have worked in the nuclear industry, such as yourself and even myself, there is a scheme in place to do that. It's well tested. It's been robust. And the issue --

DR. JACKSON: There are lessons we can take from that.

DR. EPSTEIN: Yeah. And the issue for the elected officials is should that be applied to what has happened there?

DR. JACKSON: Dr. Muro, your thoughts about that? Yes? No?

MR. MURO: Because there is a similar industry precedent, I think it seems to make sense.

DR. JACKSON: Dr. Ebinger?

DR. EBINGER: I would just add I think the Department of the Interior has been asleep at the switch, particularly during President Bush's years, and we're seeing that come home to roost.

DR. JACKSON: Dr. Rabe?

MR. RABE: This is a triggering moment. We know environmental policy is usually made after triggers. Sometimes it's good policy, sometimes not so good.

DR. JACKSON: Congress and the staff has to cover a million things. These things affect metropolitan areas and places where people live. We need to understand the global context, and we have to ask people the right question because may be we don't ask them are they willing to pay $15 a month for climate

change mitigation, but $15 to transform our energy industry through innovation into a globally competitive framework because the rest of the world, with or without Copenhagen, is moving there anyway.

Thank you very much. (Applause)