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PARTICIPANTS:

LUNCH SESSION: TRADE ISSUES IN U.S.-CHINA CLEAN Energy Cooperation

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SESSION 3: U.S.-CHINA COOPERATION ON CLEAN COAL AND CARBON

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P R O C E E D I N G S

MR. LIEBERTHAL: Our lunch speaker is Michael Eckhart. Mike is the head of ACORE, which is a nongovernmental association that focuses across -- really across the full spectrum of renewables. I've asked him to come -- this kind of grows out of an earlier conversation he and I had -- to address the trade issues in the U.S.-China clean energy relationship. A lot of comments have been made recently, most notably on the front page of the *New York Times*, about Chinese practices that may amount to unfair trade practices as they try to promote their clean energy industry. Mike knows both sides of this quite well and may help us put it in perspective, and this helps to define the political context within with the other things we've been discussing will unfold. So, delighted that Mike is here. He'll talk for about 20 minutes, and then we'll open it up for Q&A.

Mike, the floor is yours, and thank you for coming.

MR. ECKHART: Thank you, Ken. Thank you, Ken, very much. It's a real honor to be here.

I hold -- somebody's BlackBerry is up here. Ken, is this yours? Is this possibly yours?

MR. LIEBERTHAL: Thank you. Yeah.

MR. ECKHART: Good.

And I was to travel next week to the forum in Beijing and booked the flight some time ago, and I have decided well, I'm going to go anyway, so I am going to China on Tuesday. I go about twice a year and usually for forums like (inaudible) Brookings. They are held by DOE and that kind of thing, so I'm a very interested party here.

But I will say given -- not -- I'm going to give you a presentation and -- but I'm giving a kind of a presentation that will tee up a Q&A and a discussion, so we're not going to take the whole thing with a presentation. I'll just tee up some things. But if I sound like I have a very strong opinion about things, don't believe that. I mean, this is a very fluid situation, and I'll give you my thoughts as of today, but I would suggest that those are my thoughts as of today. It may

not carry over till tomorrow, okay? It's that kind of a situation as new news comes in.

All right, with that being said, I'll just start with the issues we face and share with the Chinese and everyone else around the world. A little brief on ACORE and what we do -- China -- a little bit on U.S. renewable energy sources, strategies, and issues. So, what I'll try to do is put it in context.

I'm just not going to talk about trade. That's one slide in here to put things in context, and I know we share this, but I use this to say that of course we're not just going after climate; we deal with the environment, national security, domestic energy supply, job creation, economic growth, wealth creation -- all the reasons you do renewable energy. But keen on the climate.

And we talk about, you know, forest management, agriculture practices, efficiency, buildings, vehicles, fuels, power, renewables; and then we look at the globe and think oh, my God, can I really affect this -- this is not affectable, this is too big, and what we're tweaking around with can we really do this?

And I think it's all how we see problems as to whether or not we can succeed with it, and I just used the photography here to make the point that the way we see things can motivate us about what we're going to do. So, a different perspective on the earth. I think this is the one that I appeal to. The other one I can't deal with. This one I can deal with. This says that the little layer we live in -- land, water, and air -- is affectable. It's so thin, we can actually affect it. It's, like, how deep is the Chesapeake Bay and why are oysters relevant? It's because it's so shallow that what's on the bottom really matters. Same thing here at the earth's level. So, the same words apply to this photograph, and suddenly I think we can achieve something. I'm motivated to do something. I'm working till midnight at ACORE, because this is important, and we can actually win this thing.

All right, so we founded ACORE in 2001 with this in mind. I was part of the gang of Europe in the late 1990s, what I call being in Philadelphia in 1776. All of the ideas we deal with and the efficiencies, sustainability, and renewable energy policy were born in the late '90s in Europe in a big rebel-rousing, tumultuous time, and we're still implementing those ideas. So,

what we did is I came back to the U.S. and with friends said we need to get everybody together who make renewable energy successful in our country. And that's just not industry with trade associations. They have their job, but the true thought leadership in our space comes from the end users; it comes from the professionals; it comes from Wall Street. As I'm going around the circle here as to who's involved, you know, it comes from nonprofits, and it --

We didn't know what we were doing when we started ACORE, so we made government a dues-paying member category. So, it turns out we're the only nonprofit 501(c)(3) in Washington that federal government agencies are a dues-paying member of, because we don't take any government contract money, and that's the only way they can participate. So, USDOE is a dues-paying member of ACORE -- it's quite unique -- among many other government agencies. The associations, yes, the industry.

And very most importantly is the education sector, you know. If we're dealing with all those other circles and trying to solve the problem today, we're missing the point. This is a long term -- this is a long haul and education is really the key to our ultimate success, not what you and I do tomorrow. We're getting the ball started.

So, what we did -- that's unusual. I never had that happen -- it disappeared. Someone stole my slide. Whoever stole my slide, I want you to return it.

SPEAKER: Hit the space bar.

MR. ECKHART: Space bar. I'll hit every bar. I'll hit backwards. Did you have my little thumb drive that I handed over? We'll put it in again and run it off of that. I didn't get that back. Oh, it's right here. It's a good thing we're allotted 20 minutes. So, let's exit out of there, go back to the thumb drive.

SPEAKER: Looks like the file is blank.

MR. ECKHART: That would not be good. I didn't bring my computer. I don't -- well, my thumb drive's not here. I had a blue one.

SPEAKER: I think we don't have it here.

MR. ECKHART: I gave it to Theresa. Go find Theresa.

How many of you are scientists -- will do this kind of thing? Almost none. That's

interesting here at Brookings. How many are lawyers? Come on, be honest? You got to be kidding. No lawyers? We're in Washington. Thank you. One honest person. You're all lawyers; there's one honest lawyer. All right. So, what are the rest --

All right, thank you.

So, then how many are policy wonks? Not many of those. So somehow I'm not discovering this audience. How many work for the government? We're getting there. How many work for nonprofits on Mass Ave.? We're getting there, okay. And -- okay. So --

SPEAKER: I have one here I think.

MR. ECKHART: You have one over there?

SPEAKER: All right.

MR. ECKHART: There we go. We're going to get this. There we go. ACORE at Brookings. And let's just see if indeed -- we're good. So, excellent, thanks. Okay. Hey, we're there. Okay.

So, what we do is convene and bring people together so that all these thought leaders in all the circles can meet each other, form coalitions, and we can move this agenda ahead.

In 2002, we convened the first meeting in a renewable sector on national security and made that connection. In 2004, we brought in Wall Street. Right there, that's our Wall Street conference at the Waldorf Astoria -- 700 blue suits -- and we got all the stars in the business in one place. And as I said on the bottom, in 2 weeks and 10 days we hold the same event in San Francisco with many of the same speakers. And the rule here -- sorry about lawyers and consultants, we don't let you speak in this conference. It's a hundred percent transaction professionals, commercial bankers, investment bankers, investors, and so forth, that are doing deals in the space -- talking on the stage, and that draws the others.

And what was our point here? So many newbies are coming into our space at a senior level that didn't grow up in their careers doing renewables, and we see that as a major risk of errors. Big errors with big money on Wall Street. So, we have to educate these managing director-level people fast, and we designed the conference that does that.

And the leadership counsel. Same kind of thing. Lots of CEOs coming in the business from Telecom and other places. They don't have a network in the industry, and political power is all about networks of CEOs. That's what's political power. And they do work through the associations but on a cross-technology basis -- solar wind, geothermal together. This is a dinner we have every year in the Library of Congress, and it's about getting the leaders together and in a leadership mode and asking them to step up out of their jobs and get in here and affect policy.

Now I can move on to China. We started with China in 2004. We started coming, and it's our -- Germany and China are our two focal countries, and we literally convened the first renewable energy conference in China when they passed the renewable energy law here 1-1-06. We did this in October/November. It's October 2006.

We immediately put this together with the Chinese Wind Energy Association, Chinese Renewable Energy Industry Association, the Chinese Renewable Energy Society, plus the World Council, ourselves, Enron, and the European Renewable Energy Council. And we brought them all together, and my associate at the time, Jody Rocelle , still speaks fabulous Mandarin and we were able to be the coordinating force with that in working with the Chinese to really get international attention on renewable energy in China.

And my opening speech at that conference was, "You just passed a law that says you're going be 15 percent renewable energy by 2020, and in my opinion we're not even close until you're 15 percent nonrenewables by 2020. You got this thing -- okay, good start, but backwards." And at that point, there's a big famous phase that flew around for a long time that I coined in that speech. I was going to say, "You're installing 55 gigawatts of Europe coal." But in the speech I said -- I didn't say 55 gigawatts. I said, "You install one coal plant a week in this country, and that's outrageous." We need to -- and that flew around for a number of years.

So, Enron was there; the leaders of China were there. (inaudible), who headed renewables and the NDRC at the time was speaking at that. We really engaged. And the strange thing is our whole orientation was how can we get China to do renewable energy. In 2006 -- this is only four years ago -- we literally had that thought, and how things have changed,

and how they've changed we went -- and these were the scenes in those days -- the autos and realizing that if they have 20, 40 percent of oil consumption where are we going to be in this world.

And that's a photograph, and actually it's no -- it's a one-to-one. There's no photographic trickery. That was a sunny day in Wuhan when we flew in and you couldn't see the ground because of all the white clouds and then you got down on the ground and you realized there wasn't a cloud in the sky. It was smoke. And you just can't believe that this -- I know a lot of you -- how many of you have been to Wuhan? I know. I think -- now we found out who you are. Okay.

Of those who raised your hands, how many understand that that's an accurate picture of Wuhan? Yes? Thank you. Okay, we're there.

All right, scoreboard. There's a key slide. Key slide, okay? China goals have upped -- we all know that -- from 34 years ago to 150 gigawatts in wind; solar up from 1 to 20. But here's a scoreboard here on what's happened. Bottom line. In the year 2000, the U.S. had two large wind turbine manufacturers. The two. The two. All right, and that was G.E. and Clipper, and both were founded by the same man, a man named Jim Dehlsen, who founded Zond, which became Enron which became G.E. Wind. They were acquisitions and when they bought him out, he turned out and started Clipper. So -- and it was one year old at that point. So, one man founded both these companies. We had two and they had two. China had Goldwind and Sinovel. It had just been formed the year before in 1999. Okay, fast-forward. Here we are in 2010, and where are we? We have two, and they have 83. Okay.

And then PV is a more stunning story. In the year 2000, we had five that were Shell solar and BP solar -- Shell Solar in Camarillo, California; BP Solar here -- United Solar up in Troy, Michigan, and two in Massachusetts -- ASE in Billerica, and Evergreen. So, we had five and they had five. They had Suntech. It was formed the year before. And Yingli had actually gotten started in a small way, and they had five.

And fast-forward -- we still have five, five different ones it turns out, because BP Solar just shut down, as you may recall from the news month, and they have 528. And if you

haven't heard that number, I was in Manila at an Asian Development Bank conference in May or June, and that's a real number, and the head of Renewables for China was presenting what's going on in China. I can't believe that -- 528 -- 528 companies making some component within the solar PV industry. An unbelievable success, okay?

So, scoreboard, end of the second quarter, going in the locker room, United States in big trouble, right? China ahead. Germany scored some points, now losing. We never got on the field to play. I mean, we're still at 2 and 5, okay? We didn't even get on the field to play, and now we're looking at China maybe breaking the rules. Okay, so let's raise that question. See, here's the trade issues. And from the *New York Times*, you know, you read about cheap or free land at one-third the market value, which has now gone up three-fold, so it's now one-tenth the market value and they can borrow money against that free asset they were given.

Free site improvements. I've been there in those industrial sites out there in Wuxi and the other high-tech industrial cities where they -- and you've seen it, you know. There's a plot of land for a factory, but, by golly, there's a sidewalk around it and streets around it and streetlights and electric hookups and everything's ready to go, and all that's for free, and you just build your facility. Well, then you go build your facility and you're going to fill it with labor, and the government has recruited labor from the rural areas, trained them exactly to run your machines and installed them in the dormitory for the workers on your plot, and you have trained workers at no cost to you. And then you have the subsidized loans of course to build your factory to begin with, and we've -- that's in the *New York Times,* and what I have heard most specifically is most of these are five-year balloon payment notes where no principle or interest is to be paid for five years, and so for the startup companies that means they have no fixed cost of operations and they can sell PV at their variable cost of production. All right? That's illegal. You can't do that under WTO. That's subsidizing exports to do that.

Now, the thing that draws our attention to -- and that's the most powerful one they have -- is that they're exporting, literally, 99 percent of their PV. Almost none of their wind turbines, because that has a domestic market, but almost 99 percent of their PV is specifically export. Why is that? Why hasn't China not created the massive PV market?

Well, there's a whole bunch of reasons. The official reason that they've given is, well, PV has to come down in cost, and there's all these silly international countries around the world subsidizing PV, so why don't we, the Chinese, drive down the learning curve selling to these silly countries around the world that want to pay too much for it, and when the cost has come down then we'll install it in our country. I mean, it's like they had Boston Consulting Group doing their strategic planning work, all right? And I didn't make that up. BCG is over there and helping them figure -- I'm not kidding you.

And a second one -- I was observing once to Shui Huang, who's a former -- good friend, head of CRES -- you may know him -- member of the state council and the head of the Chinese Renewable Energy Society, and I said, Mr. Shui, I suddenly realize, you know, you don't have a Communist government; you're running this thing like General Electric. And you know what he says? You're not going to believe it. He says, oh, you know about that. I'm not kidding you. And it turns out that they have studied General Electric and that's the way the government's running, and concretely he said oh, you know about that. Well, that gave me the chills just when he said that to realize what's up here.

Okay, so -- and then the exporting permitting in the closed market. The wind market in China had a 70 percent local content for many years. They dropped it last year because of threats under WTO because the wind industry, particularly GE and Vestas, and Gamesa and Suzlon -- the Western companies -- were getting serious about going to WTO, and the darn thing is they imported all of our technology for free through joint ventures by cranking the 70 percent. Back in 2004, to meet the 70 percent requirement you had to build your blades in China, because that had so much of the 70 percent. Well, the next year they changed the numbers and you had to build your nacelles in there, in China. And in '06, you had to do gear boxes in China, and then in '07 you had to electronics in China. So, by cranking that number, the content of the 70 percent China managed to import all the technology through European joint ventures and got it all basically for free by managing that. That's illegal, all right? But they got away with it, and there it is. It's done. And here we are.

So, there's this question here in the *New York Times*, but I'm going to make a

shift here, okay? I'm going to make a big shift with this next slide, and the next slide says "Let's get honest." All right? In the U.S. federal government in the United States, we just had a stimulus package that was a hundred percent renewable energy and energy efficiency. Well, gas, coal, and nuclear got nothing. We got the whole package, all right? The tax incentives, the production tax credit we have, the investment tax credit. The production tax credit is worth 35 percent of the economic value of a wind farm in this country. The investment tax credit on solars was 30 percent. It's a 30 percent investment tax credit. That's a 30 percent subsidy. Now we have the cash grant where you can get all that in cash instead of the tax incentive, and --

(Interruption; phone ringing)

MR. ECKHART: That's one of my investors, so I'd better take it, excuse -- no. Just kidding. We'll turn that down, the sound, yeah. Sorry about that.

So -- all right, so where we are in the U.S. Then the loan guarantees. Yeah, we have $60 billion of loan guarantees in the federal government that are supposed to go out the door in DOE, and they've given them to Cylindra and it's up and building a factory with a half-billion dollar loan guarantee. How's that different from a subsidized loan repair? I mean, Cylindra -- startup venture capital of that company in California -- has never sold a product, gets a half-billion dollar loan guarantee? And believe me, that wasn't a guarantee. That was a loan from the Federal Funds Bank at 2 percent. That's how it really worked. It's said to be a loan guarantee, but it's not. It's a federal loan to the company, all right? $500 million on a venture capital backed thing.

So, are we helping our young companies? You better believe we are. How about made in the U.S. provisions? That some of the stimulus bill. Same thing as their 70 percent closed market. RD&D support? Hey, you've got PV companies in this country that look at DOE contracts as the identical equivalent to equity investment by VCs. It's free money coming in the door; you don't have to repay it. That's equity investment, and the taxpayer, frankly, got no shares for that. So, is that a subsidy, or is that an investment by the United States? It's a subsidy. And the American people got no return for it -- interestingly.

Now, at the state level, look at Michigan. Giving away old factories. Okay,

China's giving land; we're giving away factories. Well, we fit it for you, you know? -- no cost to you -- with a battery. The companies that got the loan guarantees, the two battery deals. They got the factories for free from Michigan. The labor force training. You'd better believe every state provides labor force training for your new factory. Income tax holidays? They have loan repayment holidays. We have income tax holidays. You know, don't pay taxes in Colorado for 10 years if you build a solar PV or wind -- or, you know, Vestas built a wind component and a nacelle factory in Colorado. I can't say that they got a 10-year holiday, but I know that they more or less did.

And then we have our subsidized loans at the state level. So, what I'm saying is let's keep a balanced perspective on this. You know, I'm an American standing here, but I'm the president of the American Council on Renewable Energy. If I have my American hat on, what China's done is very threatening. If I have my renewable energy hat on only, and my only -- my renewable energy hat, I think this is the most fantastic thing that's ever happened, and I've been in this business 35 years. We have been asking the U.S. Government to do what China has done for 35 years since Jimmy Carter, and we have consistently just simply failed to do that, and I go back to the scoreboard -- we're still 2 and 5, right? And they're at 83 and 528. Isn't this what we asked the U.S. Government to do? To get a renewable energy industry going in this country? We've promoted it as jobs and economic growth and these companies will pay taxes. It'll be a net tax gain. It won't cost the American people a dime if you do this strategy. And I think the thing that we're most angry about is in fact not China cheating on a -- if they cheated on a WTO, fine, take them to court, pay the penalty, and so on. You read two days ago that Boeing just lost -- U.S. Government and Boeing just lost a very similar case with Airbus suing under WTO, because the U.S. Government was providing R&D support to Boeing, which was deemed to be a hidden subsidy. So, these things come back and forth. So, if they broke the rules, fine. But let's not get all exercised and ruin our relationship with China who now is the key to our success.

Global perspective on this -- you see it here in the numbers. This is total capital investment worldwide as tracked by Bloomberg New Energy Finance, which is a very reputable group, and how many billions worldwide have gone into clean energy, which is 90 percent

renewable energy, has gone from 45 billion in 2004 to 162 last year and 2010 -- I mean, estimated 214 here in 2010.

So, we've got a five-fold increase in a very short period of time of capital investment come at -- well, it looks like a flat curve. It's not a flat curve; it's almost vertical. And we're down here in the pink, then there's Europe, and the brownish is China. So, if you look at where China was here. Not a player. Were they there, booming, expanding. And this is without buying, installing any PV or any other solar or geothermal or much biomass. This is mostly just wind in these China numbers. Unfortunately, New Energy Finance doesn't pick up the investment in the factories in China -- the 528 -- and if you figure an average factory is probably $50 million and you do the math, there's billions right there. So, there is some numbers they don't pick up. So, it's bigger than that is what I'm saying.

So, where are we comparatively? The U.S. kind of picked it up here in '06, and we're done nothing. We have gone nowhere. China in that year, 10-fold increase. And maybe 20-fold based on what I just said.

So, basically, when I was asking about lawyers -- I was once talking with a lawyer friend who does venture capital law, and he had a partner that did white collar law. I'm talking to his partner and trying to figure out -- I was young at the time -- do you know if your clients are guilty or not? Little conversation about that. And he had a big mustache and suspenders and drove a Porsche and obviously good as a white collar defense lawyer in Washington in a place where people have no money, and I couldn't understand this, and he says Mike, look, I'll make it all simple. There's two kinds of people walk in that door. One says Jim, this is what I was accused of, I didn't do it, and -- but I want to retain you. I know you're expensive, but let's talk budget. Okay, second guy walks in, he says Jim, this is what I was accused of, I didn't do it, I don't care what it cost, you get me off, right? And he says fortunately the guilty will pay anything to be proven innocent. Well, hell of a conversation. Be in my book some day.

So, where are we? I really think this is a scenario where the United States is feeling guilty. We didn't do what China did. And we were told to do it. You know, I've been

pleading since we founded ACORE, for 10 years that the U.S. would do this. But China went and did it. Remember what I said about 2006 four years ago? We were trying to persuade China to do it. And they went and did it. Let's not get angry at them. You know, we're acting indignant because they cheated and -- no, no, no, wait, wait, wait. They did what we said we were going to do and asked them to do and they did and we didn't, and now we're trying to find an excuse that somehow they cheated, and this isn't right. As I said, if they broke a rule, fine, prosecute them. But the basic thing I think we're dealing with -- the guilty are trying to be proven innocent here. The United States, being guilty in the face of this great success by China, wants to prove that we're innocent, we're not guilty. But we are. And the story from this is to get on it now, because there is catch-up potential here. You know, they haven't won it for all time. But, you know, it's half time at the football game and it's 528 to 5, and we've got to come back on the field and fight these guys one more time. This looks like an uphill game.

All right, so big perspective. I'm not going to dwell on U.S. renewable energy potential. I just want to say we have equal or better resources than China has. Those of you who have studied the geography of the U.S. and China know it's almost parallel. They have their east coast. You know, we have our wind and they have inter-Mongolia wind. They have their high desert in the West. We have our high desert plains -- mountains in the West, and so on. It's -- there's a lot of parallels here. But, actually we have a lot more -- we have a lot more renewable energy resources than China does and a lot less population to consume them all. And so I'm just -- this is an amalgamated map, if you haven't seen it, with geothermal in the West in the purple, biomass in the farm belt on the wings in the forest, wind power down the middle of the country. Concentrating solar tends to be here in the -- where the -- where you can get a sunburn, and photovoltaics where you can hardly see there, but it's the yellow background. If you notice, the whole country's yellow. Let that sink in. That was the point. We have a marvelous -- we have marvelous solar resource all the way up to Maine and North Dakota. I mean, we don't have a bad resource. This is it. We were -- we're the best, actually, industrialized country in the world. So, we have it.

I'm getting towards the end here.

Our bottom line for the United States is we have three reasons to do something and three things to do, and China did all these. We have a national security drive. We have a climate environment drive. We have a growth -- economic growth of jobs drive. Okay, that's why we're doing things. Now, what are we going to do? There's three things we can do here in Washington. Craft policy. But what's the purpose of policy in our space? We're not buying, you know, F-35s or whatever they are. We're not building aircraft carriers here. This isn't a government purchase, although government is a big customer of renewables. But what is -- just think through -- what is the purpose of public policy in renewable energy, energy efficiency? It's sustainability. It has one purpose in my opinion. It forms the flow of capital from one type activity to another. That's all it is. And it's really complicated to do, because we have $1-1/2 trillion a year flowing of capital investment in the energy industries in the world, and now we're up to 200 billion, so we're over 10 percent. But at this rate, it would be 38 years -- I did the math -- before we would be at 10 percent at the current rate. We're not going to overtake conventional energy until -- as I said about China, it's not 15 percent is the target; it's 85 percent is the target -- until we're more than 50 percent of that capital flow of a trillion and a half, we're not gaining on the problem, you know? We're actually gaining and falling behind at the same time, because all those dollars are also being invested in oil, gas, coal, and nuclear while we're trying to gain on renewables and efficiency. So, we have to increase the flow out.

Well, how do you increase the flow? You increase the flow by getting benefits to the project level and a return on capital. And that's the reason for carbon credits and RECs and all this trading and so forth is to get the intangible social benefits and try to monetize them so that Wall Street sees it in their packet. And that to me is the trick of what we're trying to do with policy -- is to take intangible social benefits, turn them into money at the project level through policy-driven mechanisms so that we're shifting from what I would describe as, in the 1800s, a true cost-based energy world. Whatever it cost to dig up or drill and transport it and add 10 percent, that's -- that was the price. So, price was determined by cost.

And in the last 50 years, we've more or less moved to a market-based energy world where the world market -- gas prices track oil prices, coal prices come up, uranium comes

up. It's market forces. So, we've moved from a cost-based energy world to a market-based energy world. And where are we trying to get to? We're trying to get -- as to what I was just saying -- we're trying to get to a value-based energy world where our values are coming in to not just market forces but our values about environment and climate and all these things get turned into money and so we become a values-driven, and I think that's the transition we're just trying to get into right now. So, it's -- I think it's a 50-year slog to get there, and around 2050 I think we'll be there as a society in my view.

And so I'll close just by sharing that what I think is going to happen, and looking back from 2050 I'd like to say that in my sense of working in the business that we are winning. We're not losing this. We're gaining, gaining, gaining. And we've won almost everything for the last 10 years, that by the time we get to 2050, I think we'll be at 50 percent renewables -- I really do -- 15 percent wind, 10 percent solar. Those shocked everybody. People just don't believe solar can become big. After that we go 300 years I think we'll be 50 percent solar. Hydro, bioenergy, and geothermal -- it all adds up, and I think we'll be there.

What's happening in the U.S. particularly is -- and I'll come back to China in closing -- is the EPA has a whole series of air quality rules coming out in the next five years. The biggest one is called a toxic air transport rule, which says that you can't allow toxics to be transported across state lines. This means no more mercury pollution from coal fire power plants. If it goes across the state line, that's a toxic, and that's an EPA reg. You can't do that. So, the utility industry itself says 20 percent of our coal capacity will get shut down by 2012 because of this rule, and the remaining 80 percent -- 40 percent is at risk and 40 percent looks pretty secure, because of modern technology. So, up to 60 percent of our coal fire capacity could literally be coming off somewhere between 20 and 60 percent in the next 5 years, all right? And it's because you go from 50 percent of our electricity supply down to about 20. That creates a 30 percent wedge, which I fully intend to fill with natural gas and renewable energy. So, we have an enormous market opening up for us just in the next five years and then carrying on.

Now, coming back to China, and I'll close with this. China's strategy, as you know -- I know you all know this -- is not to do climate but to contribute to the climate question by

managing down the energy intensity of their economy. And my friend who's in the State Council emailed about a month ago, now, urgently on a Friday saying the State Council had met on Thursday and issued a new edict, which I'm sure you've all heard about, called the "going out strategy."

How many of you have heard of the going out strategy? Okay, more than half of the audience. Thank you.

All right, so I'll summarize it as it was told to me, the new going out strategy has four parts in this energy-intensity world, and it's not like what I just described for the U.S., just different mechanism. And that is, number one, our resource companies will continue to go around and acquire natural resources around the world, particularly exotic materials and so forth -- lithium -- it's on the -- relate to the high technology industries. We know all that. It's interesting to know -- I was told -- I can't prove this, I was told though, somebody from West Virginia -- that you know who is the largest now owner of coal resources in West Virginia? China, they've been in there buying. China owns West Virginia. That sets you back a bit, huh? Okay. So, they're doing that.

Second is energy-intensive industries will henceforth build their facilities outside of China, because under Europe-driven rules on carbon and carbon tracking, it doesn't matter who owns the factory; it matters where the factory is. So, if the factory's in Angola, that's Angola's problem, not China's problem. And so if China steel companies now build all their factories in Latin America and Africa, that's Africa and Latin America's problem, and there the energy intensity of their economy goes down. And that's how they're going to do this.

That dovetails with the little insight that my associate, Jody Rocelle told me years ago, and that is that China has 40 million more men than women, and that means 40 million men won't have a wife and will be quite angry. So, what are they going to do about this? And what they're doing about that -- that dovetails with the export of the facilities, because when they build a new steel mill in Angola, there's 2,000 Chinese men that are going to be sent there to run that, okay? And one by one by one, they're taking care of that 40 million. And -- yeah, true story. You know, these -- when Boston Consulting Group goes in there, they do a hell of a job. They can

always pick it up.

And then of course -- this is unproven, but I've heard -- I've heard -- that if in rural areas of the thousand uprisings and demonstrations there are a day in China now because of the environment, if you're arrested in one of those uprisings, you're about one week away from living in Angola working in a steel mill. I know we laugh, but it's scary. I mean, geese, I wouldn't want to live there.

So -- and the last two parts -- and I'm going to come to clean energy and close. This is -- the third is high-tech industries should no longer answer the phone and ship product. They should send senior executives to live in the United States and Europe so that we Americans get to know Chinese living in our neighborhood, and they, the Chinese, get to know our markets better, our politics, and then go home and be more effective senior executives. Doing the same thing the U.S. has done and Europe has done for centuries of sending people out to live in the world and then come back and be more effective. So that's strategy number three.

And strategy number four was specifically the clean energy industries, and that was they're being criticized and unhappy to be criticized for not having the intellectual property rights, the IPR, for the solar and wind and so forth. And so their order was actually not to go out and buy patents. The order was to go out and buy the companies that have the patents. They're on an acquisition binge today in California buying up the VC-backed companies that haven't quite worked out but have patents. And in the Chinese view, the patent is nice, and many of you understand this better than I, but it's a piece of paper. What they really want is the person who invented that thing that got the patent. And you only get them if you buy the company and they'll come with, typically. So, they're not out buying patents and copyrights. They're out buying companies that have patents and copyrights, all this to do the right thing.

Well, this can be seen as insidious, illegal behavior by a guilty United States that failed to do its own job. But I prefer to say that as an American this is a reason why we need to step up urgently and build an equivalent industry and take on the world market but, secondly, give credit to China for having done what we said we were going to do and didn't do. And let's build a good relationship with them and see if we can all install more renewables and take advantage of

what they've done more than anything else.

So, thanks for having me.

MR. LIEBERTHAL: Mike, thank you very much. The schedule is sufficiently compressed, and we've got about 10 minutes for Q&A, so rather than take time myself, I'll just open it to the floor. Please, again, identify yourself briefly, and kindly make your question focused.

MR. ECKHART: Apparently I answered every question.

MR. LIEBERTHAL: Boy, I'll tell you. Well, let me ask a question, then, and see if this begins to stimulate anything.

You gave a very powerful presentation about the perspective that we all ought to have on what's going on in China and what's going on in the United States. What do you think the chances are the Congress will move toward with that perspective?

MR. ECKHART: I think they're lost in the woods. I mean, it's just sad to see that you can't even have -- we have a group in ACORE -- we manage a program called the U.S. Partnership for Renewable Energy Finance. It's 16 of the larger or largest providers of capital into the markets -- Morgan Stanley, B of A, Merrill Lynch, all the really big players in the space -- and once a month or so we bring them in to Washington to meet. We had 19 meetings yesterday -- U.S. Prep Day -- and so we just got -- I just got off a conference call and debrief, so we actually met with 19 the -- White House treasurer and BDOE and 14 offices in the Senate, and the answer's not good. The answer's not good, no, no. They're in an election mode right now. Totally an election mode. Not -- the meetings were thoughtful, particularly on the Republican side.

This one Senator told one of the investors you know, hey, can you develop a conservative green agenda? We kind of all need to be a little green and I just don't know how to do it, you know, on a conservative way of doing things. And it was so amazing that just their mindset is that with conservative philosophies they can't do green. That's amazing that they would even have that thought. You know, there's nothing political about a PV panel; it's a piece of silica, you know, but somehow a philosophy can not break that bridge, so we have a big job to

do at ACORE and other places to bring the conservative mind set that this is not liberal stuff; this is good stuff. But we're a long way away, and I'm very concerned that things are --

Going backwards here for a bit, we may have hit our high-water mark in 2008, and with the stimulus in 2009, and we're a bit in a downdraft at the moment, and I'm concerned as to whether it's a short downdraft or a long downdraft, but we're in a downdraft, to be honest.

MR. LIEBERTHAL: Yes.

MR. SHIER: Jonathan Shier with the State Department. Question in this very area, but it also is a question as it applies to China as well. In making arguments for greater investment and deployment of renewable energy, one major strain of argument is we need to do it to save the planet for climate change reasons.

MR. ECKHART: True.

MR. SHIER: Another major strain of argument, major line of argument, is we need to do it for energy security reasons to get off of Middle East oil, or however it's put -- energy independence and so on. These days going -- and going forward, which of those arguments is likely to be more compelling, or is it a combination of the two, both in the case of the U.S. political scene and the Chinese political scene?

MR. ECKHART: Well, that's the ultimate question, Jonathan, is what's going to motivate our Congress, you know, and I remind people around the world that our system of government was put in place to thwart big ideas from Europe. What's climate? Big idea for Europe. No, it was, and we literally -- we -- they created, you know, a system of government that was, you know, about the people and all that sort of business, but it was to thwart being taken over by big themes, and it's very good at that job. It's really good. And, unfortunately, our system of government is based on geographic representation, which, if you remember the map I put up, explains why we can't get 51 percent of anybody to agree to anything -- is because from their constituent representation, most of the proposals we make aren't relevant to them. Solar has its place; geothermal has six Senators; and, you know, wind power has, you know, 42 Senators, and so on, but it doesn't apply everywhere. And then you take efficiency. Well, that's farms, cities -- what's that? Sustainability. How does that apply across America? And so our system of

government is not -- doesn't handle this kind of a challenge very well, lacking in crisis that would galvanize people towards the challenge and the nature of sustainability and climate is, by definition, there's no crisis. It's a slow-moving crisis. It's the frog in the hot water. So, I'm frustrated by your question. Really don't have an answer.

MR. LIEBERTHAL: Miss -- right here.

MS. LARSON: Hi, thank you so much for your presentation. My name is Christina Larson. I'm an editor at *Foreign Policy* Magazine. Sort of a corollary to your question about the U.S. decision-making process. When you talk about --

MR. LIEBERTHAL: Speak up a little more.

MS. LARSON: Sorry. When you talk about China making decisions to do things and how it successively implemented various measures over the last 10 years, what is the decision-making body in China that is behind these decisions, or what are the factions to the extent that you can see them that are motivating the results that we've seen in the clean energy sector?

MR. ECKHART: Well, I can't speak in general, but I can give you an anecdote. I was in China about two years ago and was asked to come to NDRC one evening and they would send a car, and so they sent a car, and went down in the city in the middle of the city, if you know where NDRC is, and was heralded into this conference room. And it was a big conference room, and there were about 50 old guys in the conference room, and there was -- and I was -- I was told there was going to be a meeting about wind power. Okay, but -- well, it turned out that it was professors from Shanghai who had come up making a proposal for 7,000 gigawatts -- not megawatts, 7,000 gigawatts -- of wind -- actually wind power in the coastal plain outside Shanghai that goes out. That's exceptionally enormous, right? And they had me sitting there to see if I would roll my eyes and laugh, okay? I was their plant. I realized they're all looking at me while these guys are presenting to see if this thing holds water, because the proposition was so huge. And they sort of asked at the end -- and it was the only time there was one of those funny things they -- a woman came by and very carefully put an envelope in front of me, and it was my pay for being there. So, I took a bribe from -- it's my honorarium. I thought it would be insulting if

I gave it back. So, I carefully gave it -- I carefully brought it back, deposited it in ACORE's bank account, and made an identical contribution to World Watch, so.

I'll get another one for you.

But no, they were so thoughtful, these political hacks, if you will, to take on -- first, to take on the proposition thoughtfully, and then to bring in outside parties to give a sanity check, and then -- and if you know, they just closed last Friday. They just announced the first award of contracts for offshore wind power in exactly that area, and they're going ahead with the program, and the contract that they put out PPAs for a gigawatt, four projects, all won by state-owned entities, no private entities, and the price they bid is between 9.1 and 9.4 cents U.S. equivalent, whereas in the United States we're looking at 20 cents for offshore wind power, and so, you know, they're using low-cost equipment, low-cost capital, and instantaneous permitting. It's a different system, but I'm just saying I did witness the decision making and thought it was extremely thoughtful, very well considered over a period of time, and then they implemented it fairly quickly.

MR. LIEBERTHAL: Thank you.

We now have a lot of hands and unfortunately a lot of hands and no time. So, I going to have to bring this to a close. We have a fascinating panel on coal coming up, and I don't want to take any more of the time away from them.

So, Mike, thank you very much for coming over. Really appreciate your --

MR. ECKHART: Thank you.

MR. LIEBERTHAL: The coal panel will begin in about one minute, so please try to stay in your seats or near your seats.

MR. FRIEDMAN: I'd like to ask everybody to come back in. We'll start in just a minute.

Again, we're reconvening now. I'd like to ask the people who are outside the doors to please come inside.

Hi, there. Welcome, everybody. My name is Julio Friedmann. I'm from Lawrence Livermore National Laboratory. I run the carbon management program there. I'd like

to thank The Brookings Institute for hosting this and for inviting me and our absolutely outstanding panel to be part of this discussion.

We're going to try to do our format a little bit differently. I've asked the panelists to actually bring very short presentations, 5 to 10 minutes, and then have questions within the panel followed then by open questions after that. So when people are done with their presentations, I'd ask you to hold a moment while we engage in some discussions within the panel, and it'll still be time for question and answer to the floor at the end.

I thought that I would take a minute myself and just frame some of these issues. I'm going to start first with the global perspective, a little bit about the U.S., a little bit about China, and then cede the floor to our first speaker, Bob Williams from Princeton.

Really, we have a decade to sort this stuff out. It's really like cleaning up your room. Nobody likes to clean up your room. We have to lose weight, and nobody likes losing weight through diet and exercise. But that's really what the challenge globally is. This is one of many kinds of scenarios. You've all seen these prism or wedge analyses. This is one from the IPCC five years ago, but the punch line is when you've got a bunch of technologies, when you get all of them and when you have all of them in spades, in this particular one, clean coal and carbon caption sequestration, is the largest single fraction. That's not true for other analyses but it is for this one.

Also, if you look closely at the difference between the blue bar and the red bar, the line between them, if you don't have carbon caption sequestration, you don't ever reduce emissions, you just continue emissions at the same level. This is part of the reason this technology is so critical.

The bad news? We're way above the worst case scenario, and we have to do this much faster and much bigger than we thought we did. And that's being driven by very reasonable engineering targets. That line that you're looking at there is actually a 500-part-per-million scenario; it's actually not even a 450 or a 300-part-per-million scenario. It's quite daunting.

Equally daunting, we've never used less of any kind of energy ever. Most people don't look at these kinds of diagrams, they look at pie charts that change through time. The fact

is we use more wood than we used to as a globe. We use way more coal than we used to, and if -- when this diagram was finished in 2000, the thickness of the upper line was renewables. Now, we heard from our last speaker we've made a lot of progress in that realm, and we're looking forward to that. If all future energy demand were met through zero carbon energy sources, we would not reduce emissions at all. And that's the challenge that's in front of us as a globe.

As countries, the United States and China are uniquely positioned in this. There's a shared obligation and a shared opportunity. In terms of annual emissions, we're number two, China's number one. In terms of cumulative emissions, we're number one by a lot, and there is an historical obligation that needs to be conscienced in these discussions.

In per capita emissions, we're way up near the top; we're not the highest emitter, but we're quite high. Our energy sectors look surprisingly similar in terms of the power sector, very heavy on coal, very heavy on coal in China not just for power but also for other processes as well, and this really drives the discussion. The punch line is actually -- was written by Secretary Tu before he was Secretary Tu -- both countries need not only bold leadership and striking national priorities but path-breaking cooperative agenda. And we have to work together harmoniously and move the needle on this scale.

I thought I'd have one slide on this. Everybody knows what a solar panel is in a wind farm. Most people don't know what carbon caption sequestration is, so just a second, this is not rocket science, this is rock science. You strip carbon dioxide out of a point source, and you pay some money to do that. And when you have a highly concentrated stream, 95 percent purity or higher, you stuff it in a deep, deep geological formation.

The only reason I wanted to show you this is the vertical scale bar. This is, you know, two kilometers thick. I don't know if you've ever tried to move a mile of the earth's crust. It ain't easy. This is not digging trenches in people's backyard and dumping in dry ice. This is much more like very conventional oil and gas-field operations, and it's reasonable to think about them that way.

The United States is the Saudi Arabia of poor volume. We have the largest capacity of any nation to store carbon dioxide. China has a substantial endowment of that

sequestration resource as well.

The lot that's been going on in this space, I personally have been hectoring the people for a long time to do more. It's hard for me to do that. There's more being done, and part of that was the stimulus package and part of that was programs like the U.S.-China clean energy research centers that were just announced a couple of weeks ago.

What you're looking at here is a mixture of large commercial projects, projects funded under the Clean Coal Power Initiative, industrial sequestration projects that are funded out of the stimulus project, the regional partnerships and prior field experiments. And particularly, I want to draw your attention to the large commercial projects. There are a bank of projects that are going forward without government subsidy or with very limited government subsidy just to get them over the hurdle.

This is looking pretty good, actually, and they check all the boxes now, all three predominant technology development streams, pre-combustion/post-combustion and oxy-fired combustion. All have a place on this map now, and that shows some initiative and some action on the part of the United States. There's also increasing interest in biomass co-firing. Bob will talk a little bit about that.

In China, it's a slightly story, but in fact they're doing more than most people realize. First of all, there's been some quite decent analysis by Pacific Northwest National Labs, not only in the capacity of sequestration but where does free streams of CO2 today? And by "free," they're already 90 percent concentrated or higher. For the cost of compression in a couple of wells, you can do a sequestration project.

There's 130 million tons a year in China that are being vented from pure streams, almost all of them from industrial facilities. The ones that you're seeing over here are a handful of the ones that have been -- are announced and are being pursued. There are many more than that. I am often asked the question of, how committed is China to this? How serious are they?

Three very short examples, and we'll take it from there: This is the world's largest post-combustion capture power plant. It is in China outside of Shanghai, Shidongkou run by Huaneng Power Corporation. They are capturing 120,000 tons of carbon dioxide a year.

Right now they're selling it for soda pop. They have announced that they plan to begin an expansion of this plant so that by 2015 they'll be sequestering three million tons of CO2 from a 600-megawatt power plant. By far the largest in terms of scale and scope, they did this with indigenous innovation. This is their technology developed by Thermal Power Research Institute; this is not U.S. technology.

I will say, though, they are using the Babcock and Wilcox boiler. This is an ultra supercritical boiler which was installed in 2007.

The GreenGen Project outside of Tianjin, this will be the world's first integrated power and sequestration project at scale: 250 megawatts, 80 percent Chinese technology and Chinese gasifier, Chinese hot gas cleanup, Chinese cooling tower, Chinese air separation unit, German turbine from Siemens. When I first visited the site, I pulled it up on Google Earth, and it was in the water. Google Earth hasn't updated their map enough recently to show that this whole area was ocean, it's now landfill. And they permitted this plant in I think two months. It's 90 percent built; it should be operating in December and fully operational in July.

Their second phase will include carbon caption sequestration starting 2013 at the level of a million tons a year. This is actually part of the basis for that Duke energy partnership that was discussed earlier by Bill Tyndall.

There is a project in near Mongolia -- I'm sorry, in -- yeah, near Mongolia. This has actually been funded by the Department of Energy for a couple of years. I'm happy to be part of this project. This is around a coal to liquids plant. This is the plant here. It's a big plant by anybody's standards. I think it's 60,000 barrels a day. This is the first of five modules they are building on this site. They are also building an IGCC plant with capturing sequestration. They are also building an indirect coal liquefaction plant on this site.

This has the distinction, though, that they are piloting a 100,000-ton CO2 injection at this site. They have already begun drilling. They have finished their seismic surveying; they had planned to begin injection in December, and following the success of 100,000-ton injection, they plan within the next two years to inject 3 million tons of CO2 from this facility making it the world's largest caption sequestration project.

So China understands the opportunities that it has here and some of the things they'd like to do. In that, so do we. That's the good news. And a strong, sustained U.S. partnership is going to help both countries achieve their goals. Some of that will be done government-to-government; some of that will be done business-to-business; some of that will be done peer-to-peer. And at that I'm going to stop my presentation and turn it over to Bob Williams, who's been leading an enormous peer-to-peer effort in China for some 30 years, has been advisor to the China Council and, among other things, is one of the world's foremost authorities on carbon caption sequestration technology.

Bob? (Applause)

MR. WILLIAMS: Thank you, Julio. The title of my talk is "Engaging China in Technologies and Strategies for Liquid Fuels and Electricity Coal Production with Carbon Capture and Storage for a Carbon-Constrained World." And this would build on a very significant activity that is underway in China.

Julio mentioned in his presentation that there are a large number of chemical plants in China that emit pure streams of CO2 at a level of 130 million tons a year. If you add to that the plants that are under construction -- these are chemical plants that are under construction and those that are planned -- the amount is 270 million tons a year. And so this industry is growing extraordinarily rapidly. Whenever you make chemicals or you make any kind of synthetic fuels, whether they are liquid fuels or gaseous fuels, you automatically produce a stream of pure CO2 as a natural part of the process of making these chemicals and synthetic fuels.

What do I do to get past this here?

MR. FRIEDMANN: Press the left button.

MR. WILLIAMS: The left button, okay.

MR. FRIEDMANN: There you go. Press the straight button.

MR. WILLIAMS: Okay. Okay, thanks. So this is a map of China with a lot of pins. There are 400 pins because there are 400 of these projects that I just told you about. Okay, the large pins and the total emissions is 270 million tons, and that means on average two-thirds of the million-ton per project. The large 18 pins here are projects that emit more than a

million tons a year per project, okay, and those we think are -- many of them are very good candidates for early action CCS projects in China.

The green areas here are sedimentary basins where there are prospective CO2 storage sites, and this map comes out of a long-term collaboration we've had with researchers both at Tsinghua University and at North China Electric Power University that are likely to be intellectual leaders in the quest for a low-carbon future based on fossil fuels.

Now, the reason this is interesting is because this activity in the chemical industry could very well lead to major activity of a similar nature in the production of synthetic liquid fuels or synthetic gaseous fuels. And the reason that's significant is because much of this activity is not taking place in the chemical process industry as we know it in this country where the chemical process industry is based mainly in natural gas and on naptha from oil refineries.

Instead in China, which has very little domestic oil and gas, most of the chemical industry is rooted in the coal industry, and so these 400 projects represent 400 modern coal gasifiers, okay, and China has much more experience with modern coal gasification technology than any other country in the world, including the United States, but none of that until this GreenGen Project comes on line that Julio mentioned is in the energy industry. It's all in the chemical process industry.

Okay, but many of the CEOs of these chemical plants, who are also involved in the coal industry, want to move beyond the chemical activity and get into the liquid fuels and electricity business because those are much larger markets than the chemical -- our markets that are now being served. And this is all based on gasification which is partial oxidation. When you burn fuels, you make CO2 and H2O. When you gasify fuels, you do partial oxidation, you whack off the second O, and you make H2 and CO, and you could take that H2 and CO in a carbon-constrained world and react the CO with steam to make CO2 and hydrogen, and you could put the CO2 under -- you would capture the CO2 and put it underground and make electricity with that hydrogen in an IGCC plant.

That's what they're going to do in this GreenGen plant that Julio mentioned here, but if you're going to do gasification, it really doesn't make much sense just to make electricity out

of it because once you have these two molecules hydrogen and CO, you can do all kinds of chemistry with that. You can make all kinds of chemicals, you can make synthetic fuels -- whatever kind of synthetic fuels you want -- or you can also make synthetic fuels plus electricity,

And what our analysis shows is that in almost all circumstances, if you're going to make synthetic fuels, it makes a lot more sense to make electricity as a major co-product and not just make synthetic fuels. And this turns out to open up an enormous opportunity for decarbonizing electricity at a small fraction of the costs that it would take to decarbonize electricity at a stand-alone power plant.

Here I have a set of technologies that I'm going to compare. At the top it's a pulverized coal plant that vents CO2. The next is the IGCC plant with carbon caption and storage. That's like the GreenGen Project in China that Julio mentioned. And then I have some things here that's CTLE. The means coal to liquids plus electricity with CCS.

Okay, the next one down here is the same kind of plant except that about 12 percent of the input is biomass, okay? The next one is 40 percent of the input of that is biomass. And this is natural gas combined cycles here, you know, which are the dominant technologies in the United States at the present time with regard to carbon mitigation in replacing existing coal-fired power plant, and I've also added on nuclear here.

Okay, and what I'm going to show you in the next couple of slides is that these plants up here that coproduce electricity and liquid fuels with carbon capture and storage, which are all going to cost of the order of less than $1.5 billion, are going to be highly competitive with nuclear plants, okay, in particular.

If at this -- at $4,000 a kilowatt for nuclear which is an estimate that was made in the MIT future of nuclear power update study in 2009, then this particular plant here with 40 percent biomass would produce electricity at a price when the greenhouse gas emission price is $50 a ton of CO2 equivalent. which is equivalent to 50 cents a gallon of gasoline, and if the oil price is $100 a barrel, it would require a nuclear power plant -- capital costs would have to be $1,500 a kilowatt in order to be competitive with these seen in a carbon-constrained world.

So how do you think about carbon mitigation for these systems? I want to

introduce two metrics to talk about the --

MR. FRIEDMANN: You can stay close to the microphone.

MR. WILLIAMS: Okay. Two metrics, we're talking about greenhouse gas emissions mitigation. And what I call the greenhouse gas emissions index, GHGI, which is just the ratio of the total fuel cycle-wide greenhouse gas emissions for the system divided by the greenhouse gas emissions for the conventional fossil energy displaced -- which I defined to be in this case since I want to talk about making liquid fuels plus electricity - crude oil products and a new pulverized, supercritical pulverized coal plant that's CO2, okay?

And the other is the total greenhouse gas emissions avoided. And since I'm going to be talking about electricity, I'm going to measure the greenhouse gas emissions avoided per megawatt hour of electricity, and show you what these look like for different systems. And these are the two indices on this particular graph: the green arrow -- the green line here is the greenhouse gas emissions index. And you can see for nuclear, for example, it's zero. Okay, zero greenhouse gas emissions. And the bars here are the total greenhouse gas emissions avoided in kilograms of CO2 equivalent per megawatt hour. And I want to call your attention to a couple of different things.

Notice first of all that this plant that uses only coal with carbon capture and storage, that's a greenhouse gas emission index that is essentially the same; it's for a natural gas combined cycle that vents CO2, okay? And notice that all of these systems in here have about the same greenhouse gas emissions avoided per megawatt hour, including this one here with 12 percent biomass has the same emissions avoided as a nuclear power plant.

Okay, and this one over here with 40 percent biomass has 60 percent emissions avoided more than for the other systems.

Now I want to finish up by showing you what the implications of this might be if these technologies could be launched in the market in the near term. These are the emissions of -- these are the emissions of greenhouse gas in China about into 2030 which is about double what they are in 2006, according to the EIEA's projection made in 2009. And at the same time their oil imports increased from 45 percent to 75 percent.

And I'm going to do a little thought experiment and the thought experiment is that I'm going to say that suppose, starting in 2015 to the period 2030, all new power plant involve -- all new power plants involve carbon capture and storage, and they're either IGCC here or one of these three coal production systems. Coal only 12 percent, biomass and 40-percent viables. What are the implications of pursuing this if this were done in China? And this is a purely imaginary, imagine every thought experience; it's not going to happen, okay? But it's a thought experiment that is interesting because the economics look very good.

And this is what would happen under these scenarios. And you notice, by the way, that these are the emissions of greenhouse gas emissions under business-as-usual scenario. And I want to call your attention to the black line and the green line here, if they represent and IGCC plant and the one -- and system with 12 percent biomass. I think that this one is feasible with the biomass supplies that are available in China, which is going to be largely in the form of crop residues, and notice they're about the same level of emissions reduction. And the total emissions reduction relative to business as usual is about two gigatons of carbon per year, which is one-third of total Chinese emissions of greenhouse gas emissions at the present time.

The difference between these two is that the coal production system is going to be far more cost-effective than the other system. And why is it more cost-effective? One is that the cost carbon capture is very low.

Secondly, the efficiency of electricity generation is extraordinarily high compared to any stand-alone power plant.

Third, you've got an enormous credit for the crude oil products displaced if the oil price were $75 a barrel or high.

And fourth, these have extraordinarily low minimum dispatch costs. And, in fact, these systems would be displaced before nuclear plant and, in fact, they have a minimum dispatch cost of zero if the oil price is greater than about $75 a barrel.

And this is what happens for all of these scenarios to oil imports. With any of these coal production scenarios here, oil imports in China would be virtually eliminated.

The reason I think this is important for the United States is that this is a very good strategy to pursue for the United States as well as for China, but in this country the coal industry is not in the position to become technologically aggressive in pursuit of this kind of technology. In fact the way I caricature the coal industry in this country is that they think the coal is a rock you take out of the ground and put it in a train.

Okay, in contrast to that, in China we have many of those 400 modern gasifiers that are owned by coal companies. They're very aggressive in this chemical industry expansion, and many of them, as I have said, want to get into this liquid fuel and electricity production activity, and I think we ought to exploit that in working with China. (Applause)

MR. FRIEDMANN: Thank you very much, Bob.

Just a quick aside before I introduce our next speaker. I wanted to point something out about following Bob's talk here. One of these stars in the United States, the TSEP Project in Texas, is exactly one of those kinds of projects. It is in fact the biggest of them, too. It's a 700-megawatt project. It has 90 percent capture and will produce ammonia and electricity together. This was selected by the DOE under their Clean Coal Power Initiative, and they have actually, are getting to break ground very shortly.

Before I introduce my next speaker, Jonathan Lewis, I want to say a few things about Jonathan, and I apologize to Sarah. I want you to go on third for sneaky reasons I'll explain later. But I was startled after working with Jonathan for many years. Jonathan is somebody I hold up with high regard. He's got deep technical expertise, he's got immense business savvy, and is just one of the most likeable people I've ever met. I was astonished to discover he's a lawyer, and with that I would like to leave and produce Jonathan from the Clear Air Taskforce.

MR. LEWIS: Thank you, Julio, and thanks for having me. It's quite an honor, and I'm real excited about this discussion.

I'm going to run through pretty quickly just a set of challenges and opportunities that we see and how we're approaching them. Mostly, I would just say a way of teeing up what I hope would be sort of a lively discussion afterward. It's a little bit (inaudible) right after a meal I'll run through very quickly.

There's compelling evidence out there that the key countries -- China, India, United States, others -- are going to continue to use coal for decades. They're going to use a lot of that coal. The CO2 from that coal is going to continue the issues prior to the climate challenge that we're facing, and to the extent that climate civilization is doable, it's only going to be doable if we can figure out how to manage that coal use over the next few decades. So, consequently, we think that we need widespread deployment of carbon capture utilization and sequestration in order to achieve those goals by mid-century.

The Clear Air Taskforce main focus and the primary objective of our work with Western and Chinese companies is this climate change mitigation. So the slide behind me is really a reminder to me as much as to anyone else that there are larger issues at stake here when we talk about cleaning coal in China than just it's climate profile. The Clear Air Taskforce is proud of the work that we've done in getting the United States to help reductions in NOCs and SOCs from their coal fire power sector, and we want to -- we think it's important to recognize and applaud similar efforts that are underway in China.

CCS is not going to get deployed broadly whether in the United States or China or elsewhere until costs come down significantly. So while we think it's important to engage China in the development of global and regional climate regimes, we also think there is a lot of very productive work we can do with Chinese companies in the interim to accelerate the development and deployment of carbon capture utilization and sequestration, other critical low carbon and energy technologies.

The drivers that we see in China that are driving this opportunity are direct -- are an economy that is growing much faster than we see -- you know, than ours in the West, a deep government interest in support in moving these technologies, very fast and inexpensive project development for, you know, a variety of reasons some of which we -- you know, some which we're comfortable with, some which make us less comfortable, but nonetheless are fast and cheap. In relatively scarce oil, which really drives a lot of interest in enhanced oil recovery, which really drives a lot of expertise in CCS. It's a very similar sort of technological skills that are necessitated by both technologies

The barriers to carbon capture utilization and storage throughout in China are partly technical and partly business and political. On the technical side there are challenges for sequestration that the Chinese are still working on. The expertise is scarce. It's a sort of a similar analogy to the Negro situation which was discussed earlier in that they are rapidly graduating engineers within this field, but they don't have nearly the amount of expertise that American firms and other Western firms have in areas like carbon injection.

And also there is this longstanding -- there's this longstanding practice in which the oil companies in China which control the geological data that is necessary to use CCS are not readily sharing that data even with project partners that they're working with. That's starting to -- that's starting to work itself out a little bit but it's still a significant barrier to moving CCS in China.

And then, you know, the area that we're particularly focused on, private sector collaboration, is difficult. As probably a lot of people in this room can attest, there's a lot to be gained from it, but it's a tough and heavy slog at times. There are practical and cultural differences which is doing business in very different cultures and business settings. There's financial involvement of the governments. Doing a joint project that involves, that requires government backing is very difficult to achieve when you have to decide whether or not to do that project in China or in the United States. It's difficult to get the other country to significantly invest or back that sort of project. And so that's something that we're also working on.

Then there are elements of our particular business cultures that are worrisome to our potential partners. And Chinese companies have a difficult time understanding and grappling with the liability laws that we have, you know, people developed here in the United States, and Western firms are very concerned about IPR protections in China.

These challenges should not obscure the significant opportunities that we see, however, to collaborate with China. The countries have a shared interest in decarbonized coal and, frankly, a shared dependence on decarbonized coal, ultimately. They have complementary strengths. China is the world leader in gasification, as Bob just described. The United States is the world leader in carbon injection, and it's not necessarily a zero sum game as we see it, you know. It's the way it's commonly portrayed in the press, but we think there's significant

opportunity to really grow this market by working together, by linking up Chinese firms and American firms. It's not going to be -- it's particularly in the power markets, how can any winner take all? You know, the power and, with the possible exception that China now owns West Virginia, for the most part power markets in the United States will continue to be served by power companies in the United States.

CCS's approach to seizing this opportunity has been to focus hard on the innovative companies in China and the Western energy space, and to sew up a partnerships between them that are built around collaborative projects that will accelerate commercialization of low carbon energy technologies. Some of the work that we've been doing is listed here. The next couple of slides I'm going to just very, very briefly mention two efforts that we've started that are really aimed at putting together what we think are the most innovative companies and letting them figure out how their businesses can mesh and how they can together accelerate the development of these technologies.

We're starting to reach into India. We're looking at Korea as well for potential opportunities, and what we've found is, you know, in the successes that we've seen -- I'll mention a few of those at the end -- is that once you get a little traction in this the returns are coming in very quickly. One of the first companies we worked with in a sort of significant way in this project was Duke Energy. And Duke Energy's relationships that they're developing with Huaneng and with ENN, and with others has really encouraged some of the other companies in the American energy sector to follow suit very quickly.

The first of the two sort of third-party projects that we set up is the Asia Green Coal Initiative, again focused on coal specifically. That was reasonably successful, successful enough that then the companies involved say, listen, we have a very diverse portfolio of energy interest. We really like this approach. We think it's bearing fruit for us. We'd love it if you guys could help us apply the same approach to the rest of our portfolio. And so that led last year to the incorporation of the Asia Clean Energy Innovation Initiative. Our main -- because of the sort of outside role that coal plays in this carbon challenge, decarbonized coal will continue to be our main focus, but later to each now we're hosting our first executive roundtable on something other

than coal. It's going to be on solar or thermal power in Beijing the middle of next week.

And so I'd just like to conclude with the picture, just a small sampling that's one of the companies that we've worked with to set up relationships. These are some of the announced relationships; there are several others that are sort of preannouncement, but very, very exciting. And what I think is interesting about these relationships is that they sort of defy easy categorization. When we first started our project, there was the assumption that, okay, China can build thing quickly and cheaply; United States has key technologies. That was just sort of a very stock reflection of our ignorance at the time. It's really been a two-way street in a lot of different ways.

The relationship between -- keep your eye on future fuels -- future fuels, it's licensing. Keep your eye on technology for development in the United States, in Europe, KBR and Dongguan . That is KBR Technology, gasification technology that is being commercialized for the first time in China.

Duke and Huaneng and Duke and ENN, those are both I'm going to use that are extremely wide-ranging covering pretty much the whole range of energies, energy systems in Duke's portfolio, and involve all sorts of things including financial investments by ENN in Duke projects.

So that's -- this is what we're working on. We think that continuing to focus on private sector collaboration like this is -- it's critical and protect -- it's essentially necessary right now when things are moving reasonably slowly on sort of the policy track.

Thank you. (Applause)

MR. FRIEDMANN: Thank you. A quick follow-up to Jonathan's presentation if you have not seen, the Clean Air Taskforce put out a remarkable document about a year ago called "Coal Without Carbon" that sort of gets under the skin of a handful of these carbon technologies, including geological sequestration, carbon capture, gasification, and a number of others. I encourage you to ask Jonathan about that afterwards.

We are truly blessed in the next speaker, Sarah Forbes, in that she didn't bring a PowerPoint. But we're blessed in many other ways, too. Sarah has had a wide-ranging career

working in government and industry in nongovernmental and sort of environmental groups. She has led the efforts with the World Resource Institute for a number of years in clean coal technology, and throughout that one of their guiding principles has been working closely with China.

A few years ago she began a project through State Department funding under the Asian Pacific Partnership to take the guidelines which they developed for CCS in North America and work with a number of luminaries in China to help them develop their own guidelines for themselves. That is culminating very shortly, and they're looking forward to the next phase of that.

Please join me in welcoming Sarah Forbes. (Applause)

MS. FORBES: Good afternoon. It's always fun to be the last speaker. I want to talk just a few minutes before I get started on WRI's views on carbon outside capture and storage. I have the pleasure of leading WRI's work on CCS.

One thing that we do when we convene groups to talk about CCS is we table the question on whether or not any one country, company, individual should do CCS. And we talk instead about how to do it while protecting people and ecosystems. So the work that Julio mentioned that we've done with Shanghai University and developing guidelines for China has been done under that premise, not that China should do CCS or even that the U.S. should do CCS, but that if a country decides to do CCS, how to do it responsibly.

What I'm going to do in my few minutes today -- and I am going to keep my remarks fairly brief -- I'm going to do two things. First of all, I'm going to add what the other speakers have mentioned a little bit and talk about why coal, why CCS, and why the U.S. and China. I think there's some -- a few facts that I can bring that will add to that discussion a little bit more richly. But the heart of my comments are going to we summarized the first-hand view of China's CCS-related work.

Julio mentioned the project that we've been doing with Shanghai University this August. We did what's called the "study tour." This was our final study tour when we went to China and we saw first-hand what they're doing on CCS. We added a team of experts from the

U.S., and what I'm going to do is I'm going to give you -- there are five key takeaways that we brought back from that trip. And, hopefully, it will help bring out -- and one thing I'd like to say is I think these takeaways that I'm going to mention are things that are very specific to what we saw in CCS, but I also think they highlight some of the cost-cutting issues on other technologies, and we'll pry into some of the other technology issues that we've been talking about today.

So first of all, why coal? Why CCS? Why the U.S. and China? First of all, China's coal reserves account for 14 percent of the world's totals trailing only the U.S. and Russia. We all know China's economy is growing quickly, 10 percent every year between 1980 and 2010, and China's developing as a result of that. The energy consumption in China is expected to double by 2030. We know the investments in clean energy technology in China are unprecedented. Fastest-growing wind energy sector in the world, but coal is still expected to account for 50 percent of China's total power generation in 2030.

In the U.S., we use just under 50 percent now, and I think we heard some optimistic thoughts on what that might be in the future, but the U.S. is also relying heavily on coal today, and we have pretty vast coal reserves that a lot of industry wants to use.

I want to talk about two key reports that have come out of China recently. The first is the 2050 China Energy and CO2 report, and the second is the China Human Development report. These are efforts that brought together some of China's best macroeconomic modelers. Then the consensus that emerged from these efforts is that energy efficiency advances will enable China's greenhouse gas emissions reductions to grow at a sustainably lower rate than would happen under a business-as-usual scenario and will be responsible for the bulk of your avoided emissions up until 2030. You're also going to see some substitution. You'll see more renewables, more nuclear energy and fuel switching to more natural gas. Taken together, the energy efficiency switching to lower carbon fuels will allow for the emissions to flatten but not decrease. They'll reach a peak and then they'll flatten.

Without CCS, the models are showing the CO2 emissions will not decline. So one of the things that's coming out of these many modeling efforts is that modelers in China are starting to put a role for CCS in order to enable that decline in emissions after 2030. What the

models are showing right now is a small role for CCS beginning in the next few years, growing in importance between 2020 and 2030, and then reaching deployment after 2030.

You know, when we put that into context and we think about emissions trends, the importance of a technology like CCS becomes apparent. A lot of times when I talk with people about technology and about CCS, everyone wants to talk about their favorite technology. The very first CCS conference the Department of Energy held, it was actually that way within CCS. There were some people who were talking about geologic storage, other people talking about ocean storage, and other people talking about biological sequestration.

You know what? When it comes to climate change, we need to put everything on the table. So it's not just about renewables or CCS; it's about how do we solve the vast climate challenge and what relative roles the technologies will play.

China and the U.S. are, as we've heard and we talked about today, the world's two largest CO2 emitters. They both have favorable geology for CCS and prolific resources with coal, and also projections that they're going to continue to consume coal. Both countries also have quite a lot to gain from collaboration on CCS. It's been identified as focal point for collaboration for some time, and we see more and more movement towards that.

WRI published this document in 2008, and I had the pleasure of working with Julio and a number of stakeholders from industry, academia, and NGOs on developing it. Our efforts with China are designed to produce a report that's similar to that for China. The guidelines for China are very different than what we did for the U.S. They've very different than what many other countries are doing in collaboration with solving the environmental regulatory challenges of CCS in China in that we're developing guidelines for China with partners in China. They're being written directly in Mandarin, and they're being written directly for Chinese policymakers.

The project is led by a steering committee with U.S. experts on CCS, and it also includes experts on the Chinese side that represent the major industry players in CCS in China and the leading academics. Over the course of the last two years we've taken study tours both to the U.S. and to China. I'm not going to talk about the study tours where we brought the Chinese to the United States. There have been tremendous experiences. I'll say briefly that this last

March we brought a delegation in, and we went to the oil field in Mississippi and West Texas, and we all went out and we learned about how the pipeline companies in the U.S. are making good business out of transporting CO2, and we saw where the CO2 is being injected, and it was a great learning experience.

But what I'd like to talk about is to give you the five key takeaways that the U.S. experts had from our most recent journey to China, which was in August of this year. During this most recent journey, we went to the Jilin oil field in the Jilin Province, and we saw where the CO2 injection demonstration is being led by Petra-China. We went to the power plant that Julio showed pictures of that's outside Shanghai where they're capturing CO2 in a post-combustion process.

We went to see Shanghai Electric's manufacturing facilities. We saw state-of-the-art manufacturing facilities for steam turbines that apply to coal-fired power plants and nuclear power plants, and also wind generators. And we also went to one of Tsinghua's research facilities. The year before we'd had the opportunity to visit, and Julio also showed a picture of this -- we also had an opportunity to visit the giant direct coal liquefaction plant in Inner Mongolia. Well, this year we went to see the research facility that led to the development of that plant.

After the tour, we had a call with the experts, and these are -- this is my take on what I heard from the experts from the tour: First of all, I think that as a group we were quite encouraged by the progress that we saw in China. Although China's just now beginning its R&D program for CCS, it's been going on for some years but really beginning to scale it up. There's been significant and encouraging progress. China's a leader in gasification and is shortening the gap for CO2 capture technology, EOR, CO2 storage, and pipeline transport. These are all important things that are undergoing significant R&D in China right now.

The second thing, we all know and talk about how fast things happen in China but it still surprises us. The speed of planning development construction and regulatory approval is really unparalleled in the world. The Shidongkou capture plant that Julio showed the picture of that's outside of Shanghai literally went from a patch of grass to a fully-operational power plant in a little over a year. The big Ordos direct coal liquefaction plant is up and running after just

beginning the research in the late '90s, less than 10 years from research to a giant plant that's operating today. And GreenGen is really nearly complete after just two years after its conception.

To ensure that large-scale commercial initiatives advance with similar expedience, one of the things that we started to look at is how they can do that without compromising the health, safety and the environment. WRI and Tsinghua partnered on some research that looks at the existing institution and existing laws in China that will apply for CCS and also the gaps in current law and where they fall. We have a publication that's under WRI's website on that.

And one of the things that I just have to mention is thinking looking at the speed of the thing, what's happening in China right now in the context of the stalling of projects that we see in the U.S., it's quite humbling, really hard. And that stalling, it happens on a CCS project-specific basis, and it also happens in Congress as we can't seem to make progress on climate change.

The third thing -- and I only have five. The third thing is that the experts were really impressed by the scale of investment in China. If seniors believing Shanghai Electrics Manufacturing facilities are really a monument to the large-scale investment in technology that China's making, the size, modernity, and production rates that we saw, we're really first-class. It blew every one of us away. We'd never seen anything like it. Clearly, China's investing in clean energy technology, and I suspected it may grow into a technology leader in developing solutions for the world's energy technologies, not just CCS, not just wind but technology in general.

The last thing that I'm going to mention is that one of the things that we did see was a real need to share knowledge and build capacity. China's push forward is not without gaps, and there are some really key opportunities for U.S.-China collaboration that's mutually beneficial. It's imperative for the U.S. to step up and to form collaborations that really result in moving things forward. In specific, there's opportunities for collaboration on characterizing geological storage sites for CCS, on CO2 injection, and on pipeline transport.

The history of U.S.-China collaboration on clean coal technologies dates back a long ways. The first agreement was in 1979, if my notes are correct. The most Department of

Energy, fossil energy agreement, started in 2001. I'm really excited and pleased with the China Energy Research Centers. WRI has, is lucky to have a small role in that effort, and I think we're really at an important point.

A lot of times when we think about bilateral agreements, I think that the success is often, as we see in all these presentations that we attend, that success is often just in the signing of the agreement. And I hope that we can all move past that in search of form agreements that actually are outcome-oriented and result in research and demonstration that really moves technology forward.

Collaboration is hard. It takes time, it takes commitment. And one of the things that I think it takes that is sometimes difficult for those of us from the United States is it takes a real willingness to listen. I think that's the single -- it takes the time and it takes to listen, and we're always hurrying around, and I think we don't always keep our ears open as much as we should.

In closing, I just want to say that I think there's a tremendous opportunity for some collaboration on CCS and also on clean energy technologies more broadly between the U.S. and China that can be really mutually beneficial and move forward.

And with that, I'll close my remarks so we can get to the discussion. (Applause)

MR. FRIEDMANN: Thank you. Thank you very much, Sarah.

Just a moment here before I bring the speakers up, I wanted to just say -- so before we say something, I want to say something. Often people talk about this topic, about CCS in general, where they'll talk about this topic of CCS collaboration in China and possible opportunities there as if there was no current base of knowledge at all, and this is a common misconception.

There is a roadmap that was released last year actually from the Asia Society and the Center of American Progress that detailed a number of specific recommendations around how these two countries can collaborate on this technology. That report itself drew on an immense body of literature and experience on carbon caption sequestration that's been built by many groups over the past several decades, most notably the Department of Energy; hundreds of

documents, hundreds of findings, dozens and dozens of projects. But the international government -- the Intergovernmental Panel on Climate Change, MIT, the World Resource Institute, Clean Air Taskforce, the National Academy of the Sciences last year, the Interstate Oil and Gas Compact Commission, the Enhanced Oil Recovery industry. There is just an immense body of knowledge out there to draw on.

And this actually leads us to then say, well, that isn't the actual challenge we're facing; we're facing some other set of challenges then. And I'd like to invite the panel back up to discuss what those are.

So with your indulgence I'll try to start with a fun question first. What we're seeing in both of these countries is this is an immense opportunity surrounding these projects. We see projects springing up. How do you guys see that those projects are going to serve the needs not only for the individual countries but how they can serve each other's needs as well?

MR. LEWIS: Well, I'll tell you first now today, particularly, you know, among the companies involved in developing those projects there are very ready opportunities for learning, particularly when those projects are built through partnerships.

The one example is the Shanghai post-combustion capture plant is about the same scale as the AEP Mountaineer post-combustion capture plant. They use different capture technologies, and so it presents us with a really useful opportunity to compare two potential paths forward on carbon capture.

MR. FRIEDMANN: Right, without actually building both of those same facilities within one country.

MR. LEWIS: Right.

MR. FRIEDMANN: Others?

MR. WILLIAMS: I think -- I was struck when I listened to Sarah about the importance of getting on with it. And to put this into -- into perspective in the CCS area, the International Energy Agency carried out a study in 2008 for what it would take to meet the G8 goal of a 50 percent reduction in global greenhouse gas emissions by 2050, you know, to -- and that would require of the order of 3,400 projects up and running by 2050. The G8 has committed

to doing -- having 20 projects up and running by 2015, 2016, and the International Energy Agency in 2009 came out with a CS roadmap report that said that we should, if we're going to stay on schedule to get 3,400 of these projects up and running by 2050, we need to have 20 -- or, excuse me -- 200 -- or 100 up and running by 2020. And we're just nowhere near on that, on that track.

And so I think one of the things that would be very important to do is to find ways to build on the Chinese fire in getting things moving along and see if we can find ways to expedite the process of getting back on track, not just in the United States -- we're way behind -- but Europe is behind and the rest of the industrialized world is behind, and I think there's a strategic opportunity to try to build on what China is doing and just getting projects up and running on a -- at a pace that no one else on the planet can do.

MR. FRIEDMANN: Just a quick comment on that pace. That power plant, the post-combustion capture project that I guess all of us have now mentioned, that was actually permitted in three days. And I think it only took that long because it was a weekend. So there are certainly aspects about that which are both exciting and also alarming.

In that exact context, actually, one of the things that keeps coming back regularly in this conversation is why would we partner with trying to end this context with the threat of loss of American manufacturing, the threat of U.S. jobs. I wonder how you guys would respond to that kind of a specific question.

MS. FORBES: I'll go ahead and take a first shot at that. I think one of the things that I feel is a common misconception is that this activity that's happening in China and the speed at which things are going that there are U.S. companies and researchers and engineers, and people from all over the world who are coming on site to help make that happen. So I think there is quite a bit of involvement and, you know, you mentioned that, you know, the turbine will come -- a Siemens turbine from Germany and different parts of the world, and so I think that not necessarily, it's not always a net loss even when projects are moving forward in China.

MR. LEWIS: I want to add that, you know, the Taskforce, many of my colleagues for much of the organization, is really folks then trying to develop what we describe as the CCS industry, and, you know, our first sort of area focus is in the United States but, ultimately, we think

this is going to be required throughout much of the world. And, you know, that industry is different types of power plants, power plants that are more amenable to capture. It involves the capture systems themselves; it involves a new and fairly complex network of pipelines, and then it involves injection sites and then managing those injection sites.

That industry is not going to get built either as robustly or as quickly unless we collaborate with China, with other major economies that are facing these same issues. So, you know, I think there's a lot to be gained from this transition to a carbon, a low-carbon economy, an economy a power sector that embraces CCS. But in order to realize those benefits and to realize them quickly and in a sort of climate-relevant timeframe, we really need to collaborate with China and take advantage of the sort of the capacities that both countries bring to the table.

MR. FRIEDMANN: Thank you. Just very quickly I would add that we invited a number of companies who are doing business in China in this sector to talk at this session on the panel. They are all not available because they are off doing business in China now. I am not exaggerating on that point.

Again, we're going to open the floor for questions in just a moment.

Still, given that between the countries and the few sorts of projects, we're still facing a number of technical gaps. We're finding a number of legal and political and regulatory gaps or challenges, including from the SEC IP, and we're also finding financial barriers to deployment in both countries and certainly between countries. Where do you see sort of again early action in the U.S. trying to collaboration as being sort of the most important in these kinds of realms?

MR. WILLIAMS: Well, I'll just reiterate what I began my presentation with, and that is that the easiest opportunities are in the existing chemical process industry in China where you have very cheap CO2. If you're making these chemicals, the cost of CO2 capture is of the order of $10 a ton of CO2. That's equivalent to, you know, 10 cents a gallon of gasoline tax.

So it is really cheap, and one of the -- and I would like to go back to your earlier question here and bring in the point as well that I think that collaboration on these early action projects with China where you can demonstrate very favorable economics in the near term for

carbon capture in storage would be beneficial not just to the U.S. coal CCS activity, but it could also be, help get a carbon mitigation policy established in the United States.

And the reason I say that is because we had two -- over the last year or so, we've had two carbon bills, you know, Waxman-Markey and Kerry-Lieberman, and Waxman-Markey passed. But that was passed by the House which represents the cities, and Kerry-Lieberman did not pass because it was in the Senate which represents the states. And the coal states have a lot of power in the Senate and we're not going to get a, in my opinion, a serious carbon mitigation policy in the United States unless you can get the coal states on board and early action, successful action, on CCS is a very good way of demonstrating that you can do CCS for coal in cost-effective ways, and that would be very helpful in moving toward a comprehensive carbon mitigation policy in the United States.

MR. FRIEDMANN: Well, let me take up with your sort of starting point here, Bob.

Again, we'll open for questions in a minute. I will let you know when that happens.

The -- I would -- I am certainly an enthusiast with the notion that these big pierce dreams of CO2 in China are great places to start. What are the barriers to doing that? Ten cents a -- or $10 a ton is more than many groups in China wish to pay today. There's no incentive for them, so where are the political gaps? Where are the technical gaps? Where are the financing gaps? And where is action helpful in this? And again, that's for the panel.

MS. FORBES: So one of the gaps -- and I mentioned this just in passing in my presentation -- but I think one of the challenges to CCS is that your geology is very site-specific. And in order to promote safety, you need to have a firm regulatory framework that can protect and ensure.

And so it's a technical issue in terms of I think there's some capacity-building to do for geologic -- for site characterization and CO2 injection in China. And then I also think there's a policy element to that in terms of thinking about how to within China's laws promote storage that's safe and secure and permanent. And I think we now how to do it, but I think that there is some opportunities for knowledge-sharing between the U.S. and China on both of those

fronts.

MR. LEWIS: The financial gap is significant, and it's inconvenient right now, given sort of that, you know, the state of the economy, our economy in particular, and the willingness to send dollars pretty much anywhere else than, you know, outside the United States.

That said, as Bob has explained, there's just enormous opportunities to be gained both for the climate and for -- and for industrial development in the United States if we were to focus on some of these really exciting opportunities, really of potential opportunities in China and aggregating CO2 from a bunch of ammonia plants and other chemical plants. And in sequestering that CO2 would represent enormous learning, and, but, as Julio pointed out, someone's got to pay for that cost. It's, you know, as relatively small as it is.

You know, our suggestion, and it's a difficult time to make the suggestion, is that the United States government should pay for an American-based company to get involved in that process to cover and defray a lot of those costs. You know, for that particular project, we think KBR would be an excellent candidate to put the -- to aggregate those emissions and set up the injection process.

MR. FRIEDMANN: That does, however, get highlighted a number of policy issues around that. Right now, even if there were a carbon market in the United States -- which there ain't -- and even with the carbon market in China which is emerging, it's not clear that a U.S. company could aggregate those kinds of projects to sequester CO2 and declare the offsets to the United States.

And with that, though, I want to go back to something that Sarah was talking to, and this will be my last question to the panel, and we'll open up after that.

It's the bogeyman in our discussions, there continues to be substantial issues around public perception in both countries around carbon capture sequestration. And even in context where the financing is good and the regulatory framework seems aligned and the companies want to go, the issue around public perception and how stakeholders receive this continues to bedevil the conversation. And I was hoping that you would all make a few comments on that.

MS. FORBES: So one of the things that we're seeing around the world as CCS projects are moving forward at bigger and bigger scales is a variety of different local reactions. There are some communities that are welcoming CCS projects, and there are others that are opposing them.

One of the things that I think is really important is to think about it again on a site-specific basis. Just like the geology is very site-specific, the unique community factors of any one place that you want to put one of these project is very site-specific, really understanding the needs of that local community having a project develop a regulator and a local -- you know, the local decision-makers, you know, in China, it may be the provincial authorities. In the U.S., it may be your -- may be your state mayor along with some key business -- you know, decision-makers within the community, having them work together and making some joint decisions on how a project could meet all three of those mutual needs at the same time is the way.

We have to stop talking about the public as a barrier to any technology deployment and start thinking about how to respect the local needs and move projects forward in a way that everybody can benefit.

MR. WILLIAMS: I think that one of the ways to address this public perception challenge is to move as quickly as we can to get a number of commercial scale demonstration projects carried out in a wide variety of geological formations.

And I want to go back to a point that I was making earlier, and that is that one of the ways to get projects off the ground without waiting for over the time that it takes to overcome these financial barriers to these first-of-a-kind projects is to couple these -- this low-hanging fruit to CO2-enhanced oil recovery opportunities that was mentioned in the presentation earlier. And the reason for that, these low-cost CO2 capture opportunities will not need any external financial support; they need regulatory support to be allowed to go ahead, you know, and meet these. But the cost of CO2 capture is so low that it is likely to be in most instances less than the market price of the CO2 for enhanced oil recovery markets.

MR. FRIEDMANN: Go ahead, Jonathan.

MR. LEWIS: All right. Bob's point is what I want to echo on, the need for some

initial commercial scale demonstrations, which brings us to sort of a different, slightly different take on Julio's question, and how do you how do you get buy-in? And for us it's the question that we're confronted with is how do we get buy-in from the companies that we're working with , you know, and there are companies here in the United States, particularly, you know, traditional fossil-based companies, energy companies, and companies in China, all have a lot of skepticism around this whole proposition and the need to sequester CO2.

One of the refreshing things about working with some of the companies that we've been dealing with in China is that despite whatever reservations they might have, they're strategic enough to understand that they can't afford not to explore and gain this learning. And so that's, you know, that's really a very important driver in this space right now is that these companies see that there is a potential scenario in which they're going to have to do a lot of this, and they need to learn about it now. They may not be convinced that they're going to need to do a lot of it, but they need to know how in case that, in case that scenario comes to play.

MR. FRIEDMANN: Please?

MS. FORBES: May I add one thing, Julio?

MR. FRIEDMANN: Sure.

MS. FORBES: So one thing that I think we probably haven't said clearly on this panel is that if a CCS project is selected in the site with the right geology, if it's operated responsibly and if its monitored and managed over the long term, it's expected to be safe with secure storage. And I think that's something that, you know, I talked about the need for environmentally regulatory frameworks. We've talked about why the public might not like it, but I think it's important to underscore that the expectation is that if you do it right, the CO2 is going to stay underground where you put it.

MR. FRIEDMANN: Yeah, it's actually a little better than that. The more we've studied it the better it's looked, actually, and things that we thought were real technical concerns turned out not to be. In fact, in many cases they turned out to be positive.

On that context again, I think all of you have mentioned the fact that getting these projects up and running, you know, a place where a politician can come and visit and kick the tire

and say, oh that's what you're talking about is, in fact, a useful thing to do in getting these projects up quickly in both countries would help that.

With that I'd like to open up to the floor. We had the first question over here. Edom, have you still got your question?

SPEAKER: Sure.

MR. FRIEDMANN: Sure.

SPEAKER: Thanks, Julio. First of all, I think this is an excellent panel, and you covered a lot of ground. Most of your discussion I guess dealt with first-stage commercial demonstration issues. You did touch on potential commercialization, and I want to focus on that and what is the potential with China. And I was intrigued by Mr. Williams' comments about the focus of the chemical plants that were coal-based that were -- that had to have the economic potential.

And it seems to me that the problem in the United States is that we don't have the coal-producing sector as deeply engaged as we do in China. In fact, in the United States, it's predominantly the electric utility sector that seems to have the biggest stake or perceives to have the biggest stake and risk of loss in not -- in failing to commercialize CCS as well as some of your multinational oil companies, actually, who also have a big say in trying to improve a down-hole injection and then for use of EOR.

Is there some way that we could marry those interests in terms of trying to come up with the proper business model? Because, ultimately, at the end of the day we're talking about phasing out commercial demonstration plants and moving to full commercial finance which is some ways off. And what do you see as the long-term potential of collaboration with China in introducing that?

And then, secondly, this was sparked by the comments made by Mike Eckhart dealing with renewable energy. To the extent that we are successful, for instance, in getting China animated in this space, are we going to be looking back 10 years from now and wondering what happened to the United States when they advance the technology, and then they're selling the technology on a commercial basis? Is that something that is likely to happen? An easy

question I just wanted to throw in your lap.

MR. WILLIAMS: I think that a very good strategy for the United States would be to encourage its coal industry to partner with Chinese coal companies and CCS projects starting in the chemical process industry. And we already are seeing some steps in that direction, at least on the part of one coal company. I believe Peabody is a partner in the GreenGen Project in China.

But that's not exactly what I have in mind because the GreenGen Project is a project that is carried out in the power sector. Okay, and I think that what we need to do instead is to encourage coal companies in this country to partner with coal companies in China starting in the chemical process industry so that our coal companies can get the level of comfort with advance gasification technologies that the Chinese coal companies already have.

MR. FRIEDMANN: Let me just make two quick follow-ups to that with respect to your question. First of all, I think that the utilities and the coal companies in this country are grossly under-investing in this area. With a couple of exceptions, I think that's true.

We have to recognize, though, that that's on good grounds. Structurally and economically, that's where they're at. They do not have a mechanism by which they can recover those investments in the rate base. The public utilities commissions of this country are structured in a way that won't allow a commercial enterprise to recoup that investment. That's an example of a barrier that we as a country need to face. Those capital challenges are different in China. It is easier to get access to the capital, but again, the way in which those decisions are made are also managed in a particular fashion.

Had a question in the back. No? Yeah.

MS. LEONARD: Hi. Thank you for the presentation. I'm Amber Leonard, Minzer Energy Group. My question goes back to the discussion about carbon -- not carbon sequestration geologically but the use of the chemical industry somehow. And perhaps some of us don't exactly understand how that would work. Would the carbon be embodied in some things in some way within the industry? Or does it get re-emitted somewhere down the line?

MR. FRIEDMANN: Okay, so I think you might be mixing two questions.

MS. LEONARD: I could be.

MR. FRIEDMANN: One of them is that a chemical process of the kinds that Bob's described produces a byproduct stream of pure CO2. And so most chemical processes start with fossil feed stock produce a byproduct stream, and that's what he was talking about sequestering.

Earlier from Duke with Bill Tyndall, we heard discussion about utilization, and in Jonathan's talk he had CCUS, carbon capture utilization and sequestration on his slides.

MS. LEONARD: Okay.

MR. FRIEDMANN: This a topic which gets reinvestigated every 5 to 10 years where somebody says, can't we do something with the CO2? And they scratch their heads and say, well, maybe we can make cement, maybe we can make algae, maybe we can do these things, and the bottom line is that there are niches which are interesting. Algae and cement are among the more promising. Enhanced oil recoveries, another one that Bob and I spent a lot of time talking about, enhance water recovery, you can use the CO2 to produce fresh water.

The punch line is if you're really styling, if you're firing on all cylinders, if you're doing everything you could possibly could do, you'll be lucky if you get 10 percent of the global emissions or 10 percent of a plant's emissions. You just can't handle that much CO2.

MS. LEONARD: And that's not significant?

MR. FRIEDMANN: It's significant, and it will pay dividends, and it'll create a value stream. You just can't actually expect it to solve your problem.

MR. WILLIAMS: I'd like to follow-up on that and put it into sort of a historical perspective. One of Julio's slides he showed the front cover of the 2005 IPCC's special report on CO2 capture and storage. And I was a coauthor for two chapters in that.

And it was very interesting in that, in that IPCC process which has a lot of input from governments around the world. And there was enormous pressure on the IPCC scientists to have a long chapter in that special report on CO2 use, okay, and the scientist just gave an enormous amount of pushback for exactly the reasons that Julio said and, in fact, outside of CO2 EOR, I don't think reuse amounts to a hill of beans, you know. There's just not any real there

there, okay.

And what we ended up with in that special report in 2005 was like two pages on reuse, it just essentially explaining that there's no there there, okay. And that's what the scientists wanted. The governments were very disappointed because reuse is a very romantic idea.

MR. LEWIS: I just want to add that fortunately, at least the Chinese government and ERC sees enhanced oil recovery as a -- puts it within utilization category which, you know, that's, right now most of the injection in the world is for EOR. And so that's an important path forward, and it's very important to the Chinese that they have this path, you know. Its long-term scale is, you know -- well, it has limits on how important it's going to be over the long run, but at least as we get started it's very important to the Chinese that they find a economic use for the CO2 as they start moving forward on this.

MR. FRIEDMANN: We're going to take only two more questions, then, and then I'm afraid we're going to have to wrap up.

You have a question here?

MR. FORSBERG: Yeah. Charles Forsberg, MIT. Two pieces of background information. First, most of the world -- China, Europe, Asia -- works under the divine right of kings, historically, on land uses which means everything under the ground is owned by the king of the country.

The United States, because of the Homestead Act of 1860-something signed by Lincoln, implies that a landowner owns land to the center of the earth. How do we address the issue of land ownership underground rights when we recognize that one of these sites covers tens of thousands of square miles? And we're going to have tens of thousands of landowners all were going to want to get paid for purely greed purposes. I hate to bring up Lincoln, but Lincoln was the guy who organized this.

MS. FORBES: This is an important issue, and I'd really welcome a discussion offline about it. I will say really quickly that that very issue has been a factor in cancelling some of the proposed demonstration projects in the U.S., but there are states that are beginning to address it on a state-specific basis. And we're starting to get some clarity there. But I'd like to

have a longer discussion about it at some time.

MR. FRIEDMANN: And the other thing about it is that the property ownership issues of poor volume are being debated in legislatures around the country and so forth, and it is being worked. In the near term, states are finding clever ways around that as well.

The Illinois basin states Indiana, Illinois, and Kentucky are talking about building a CO2 utility which will manage the poor volume at a fee. And that's an interesting solution which would handle that and would pay royalties to the landowners.

Another example is the first 10 miles of Texas off the coast are owned by the state of Texas. They can do whatever they want, and that's being pitched now as a national class sequestration repository, and that's likely to come through.

Last question.

SPEAKER: Thank you, Julio. I am from the Chinese embassy. In addition to the cost concerns and the security concerns of CCS, in China we have another concern which is the additional energy consumed during the course of doing CCS to capture the carbon and to transport the carbon, and to put the carbon underground. So it consumes, according to some experts, 30 percent more energy doing the CCS, which we think is not conducive to sustainable development.

Is it possible to reduce the energy consumed during the course of doing CCS?

MR. FRIEDMANN: Thank you. Before I let Bob answer that question -- I'm going to let Bob answer that question -- I want to unpack your statement a little bit because it takes people a while to understand this.

In the United States the only dimension that, when people say the energy bill, they're only talking about cost. In China it's not just about cost, it's about future coal resources that are being used; it's about the congested railways and the inability to bring extra coal. To offset that energy penalty and keep the same rate, you would need to import more coal. So there's additional issues beyond just cost which China considers when it makes a statement like that.

So, Bob?

MR. WILLIAMS: The energy penalty depends significantly on the technology that you want to deploy. The energy penalties are the highest per post-combustion. They're lower for pre-combustion IGCC plant, and they're the lowest for pure syn-fuels plants or chemical plants, because whenever you make syn-fuels or chemicals, you produce a stream of pure CO2 as a natural part of the process, and the energy penalty for capturing that CO2 is very low.

For these coal production plants that I mentioned here, this does not involve any advanced technology. The energy penalty is eight percent. Now, that is just if you look at the system, you know, with CO2 vented, it produces a certain amount of liquid fuels and a certain amount of electricity. And then you do CCS and you have to do some compressing work, you know, to capture that CO2 and pumped it up to 150 atmospheres. And if you make that extra electricity in an IGCC plant with carbon capture and storage, you know, it's an 8 percent penalty.

But that's the wrong way to look at this, actually, because if you're going to make electricity at a very high efficiency, you want to use these coal production plants instead of a stand-alone power plant in which case the energy penalty would be a lot less than 8 percent.

MR. FRIEDMANN: Because we're so limited on time, I'm going to try to wrap this up quickly. Just a thought here. Right now those gas separations are done at 10 percent thermodynamic efficiency. So there's a lot of freeboard in the system. We can make really steep reductions in these technologies.

The coal without a carbon report that I mentioned earlier, Howard Hertzog at MIT wrote a chapter on that identifying a number of technologies that looked very promising in that regard. I would add, actually, that both the U.S. Department of Energy, U.S. industries, Chinese NDRC and most and Chinese companies are heavily investing in this space with exactly that in mind. And it looks like the Shidongkou plant with the TPRI capture technology, in fact, uses substantially less energy than other capture technologies to date, and that looks very promising.

The last word, and that, unfortunately, has to be the last word, is actually that that is a topic identified under the U.S.-China Clean Energy Research Center specifically to look at those technologies and to think about ways to lower those costs in both countries and to assess those technologies.

And the University of Kentucky is actually taking the lead for the Winning Institution. They've had a longstanding relationship with Tsinghua. With the Thermal Power Institute I'm looking at exactly that question.

This is my favorite topic. I'd be happy to do this for another nine hours, but instead I'd like to thank the Brookings Institute again and thank all of our panelists who have been so outstanding today. (Applause)

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