

THE BROOKINGS INSTITUTION  
FALK AUDITORIUM

THE NEW DYNAMICS OF GLOBAL ENERGY AND CLIMATE  
A CONVERSATION WITH EXELON CEO CHRIS CRANE

Washington, D.C.  
Monday, October 22, 2018

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## P R O C E E D I N G S

MR. VICTOR: Good afternoon. My name is David Victor. I lead, along with Bruce Jones, the Climate and Energy Initiative here at the Brookings Institution. I'm also a professor at UC San Diego in California. It's my great pleasure to host this afternoon's event, which is broadly on the theme of the new dynamics of global energy and climate and really revolves around the future of electricity. It's hard to imagine a better speaker with us than Chris Crane and Chris' company, Exelon. Almost all the studies show that a world that decarbonizes and a world that becomes more electric is a world where the electric power system is at the center of reducing emissions across the economy. Chris' company runs more nuclear reactors than any other company here in the United States, has renewables in its fleet, has gas, they're struggling with the issues about the future of the power industry on a regular basis. And so it's great to have you with us today.

I'm going to introduce Chris in just a moment, but I want to remind everybody of two things. One is please turn off your cell phones, portable fax machines, any other electronic gear that makes noise. And today's meeting is on the record. We have reporting press in the room and coverage of various other sorts, so say whatever you want, but know that it's directly on the record as opposed to leaked on the record.

(Laughter)

MR. CRANE: This is Washington.

MR. VICTOR: This is Washington. I think as Larry Summers said, everything is off the record until it's interesting. (Laughter)

Chris Crane is president and CEO of Chicago-based Exelon. Maybe at some point today you'll tell us what Exelon actually means. They have 10 million customers. They are the largest electric utility by customer in North America. A large

fleet of nuclear gas, other power plants, they have six utilities that serve customers in a variety of different markets, including here in Washington, D.C. He rose up through the ranks at Commonwealth Edison. I believe you're the only person in the room who is a senior nuclear reactor operator, certified, so if that need arises this afternoon we know who can run the nuclear reactor.

MR. CRANE: You don't want me there.

MR. VICTOR: And is now running Exelon, the entire company. He is widely respected inside the industry. He has been chairman or vice chairman of Edison Electric Institute, the Nuclear Energy Institute, the Institute of Nuclear Power Operators, which is the organization that sees the operations of all the commercial reactors in the United States. He's on the board of directors of a number of organizations, including the Economic Club here in Washington, D.C., and Chicago's Museum of Science and History. He is a thinker and a leader and, Chris, it's really my great pleasure to welcome you here this afternoon.

MR. CRANE: Well, thank you. It's an honor to be able to speak at such an institution. We really do appreciate being able to state our voice in what we think is really a critical period. The impacts of climate change are irrefutable. I think many of us, many of our folks, or customers believe that. Just look at our last couple of years. This last summer alone, fire, flood, storms, heat waves, ocean temperatures that are drawing so much moisture into these hurricanes, and an infrastructure that we're trying to maintain during these changing times.

The electric sector is key to really helping in gaining the reduction in carbon. And as EEI and other institutions that I belong to, we take that commitment, the member companies, very seriously on what we can do. We have to consider every single source and every single option on reducing carbon and getting to a low carbon

economy, support limits in carbon emissions. As a company we would prefer a market based approach that would allow creativity and technologies to compete to be able to make that possible. We believe in the continued development of affordable renewable assets coming onto the market. It's got to be about cost, it's got to be about safety, it's got to be about reliability, but we can put the environment right on top with those to serve our customers. And, you know, developing an economic way as we continue to have to require fossil fuels because of the reliability issue, a credible way of sequestering in an economic way of doing that.

There's no question in my mind that we must quickly reduce the amount of carbon that our sector and the other sectors that are using fossil fuels are dependent on. There are four ways of reducing it, and I think we are all very aware of them. Reducing the demand. Energy efficiency has been very effective at the appliance level, at the unit home level, at the level of transmission and distribution on line losses, continuing to get more out of less generation. The use of low carbon to zero carbon energy sources is an imperative on making this. Scrubbing the carbon out of fossil fuels, I'll talk a little bit more about that. We do think that's possible, and I'll talk about some investments we're making there. And extracting carbon from the atmosphere has been a focus. Prominent scientific groups believe all of these strategies are required to meet the goals that we've set forward to avoid the catastrophic climate impacts that we've seen and we're having to live through as a company as we repair and recover our electric system for our customers and try to do it in the most efficient and economic way.

As I've said, we have to reduce these dramatically, and it's going to take a capital investment to do it, so we need to do it wisely. We cannot expect our customers to bear unnecessary costs on this road to a low carbon future. Exelon is analyzing how the U.S. economy can achieve this 80 percent reduction in greenhouse gases by 2050.

Using 1990 as the baseline year we've seen a 25 percent reduction in what our sector is contributing. But based off of all the studies that we've seen and the potential of a two degree or greater rise, we have to do something much more severe. We've heard that from the IPCC objectives and we've also heard it in the Paris Accord.

Like other studies that evaluate these scenarios we expect that dramatic reduction in emissions will be needed not only from the supply side, but also the demand side. Electrification with clean sources can be a very key part of that. To be the most cost effective to our customers, more reductions will be needed to come from our sector. We do know that, we support that as we go forward. But it's also -- and this becomes a more sensitive part of the conversation. Just recently there was an op-ed that was penned by Exelon and the MacArthur Foundation about this range of options, but also including nuclear in the range of options with the additional renewables needed, that addition of renewables. The demand side options, such as energy efficiency as I spoke of in electrification. And alternative fuels are going to be critical going forward.

The analysis that we are undertaking right now -- and I won't see the first cut of it until the December timeframe -- follows the path of what has been requested by many investor owned companies, what will the two degree rise do to your business and what will it do to the financial health of your business. Well, when a company like ours looks at the financial health of our business in some of the monopolies that we operate, it's also the financial health of the communities that we serve, the temperature changes, the impact of the storms, the severity of the storms. It is a business imperative that we feel for us to understand that risk and work both sides of it.

We are going to have to harden the system. So we've asked what does a one degree rise look like, what does a two degree rise look like. Sit down with our stakeholders and say we're doing everything possible on the reduction of carbon, but we

have to make sure that we have plan B, and that's being able to take care of the security and the livelihood of our customers. But clearly, every ton of carbon that we can keep out of the atmosphere at this point, as we're transitioning into advanced technologies, is beneficial.

Exelon has been aggressively involved in energy storage grids, scale storage. We were the initial investor and still are an active investor in an organization called Volta Energy Technologies. It's a unique company that allows multiple parties to come together and invest in commercializing national lab technologies. There is so much information within the national labs. And seeing our new Secretary of Energy supporting the national labs the way he is now that he's come into the job is imperative, but getting that technology out and commercializing it is something we need to make economic large scale storage available. We're working to preserve our sources of carbon free energy in Exelon with our 23 reactors -- makes a significant impact on that. And it's currently not getting in all parts of the country credit for the social benefit of the avoided carbon. If you look at other non-admitting sources, they all get the credit, the benefit. In some states we have been able to pass laws or regulations that allows that benefit for a certain amount of those megawatts produced to be credited. It is not a bailout. Our company lost \$800 million on two sites in Illinois over seven years trying to figure out a way to save them. Not only is it an economic requirement for the communities they serve, but the environmental benefit.

We also support the development of those who are investing in new sources of nuclear technologies, more passive designs, or more modular reactors. The reality is in the markets that we serve, it's competitive, it's based off of price and reliability. And the cost of new nuclear is prohibitive for us to be investing in. So our investments are going into storage, our investments are going into sequestering

activities, so we can bring more of those technologies in line. We do think carbon capture storage has a potential in the future. Our low cost natural gas is an advantage to the economy in this country. Exelon is an active investor in technology that we've been working on in a partnership. It's called Net Power and it has great promise to be a large scale CCGT using natural gas but capturing 100 percent of the carbon through a very complicated cycle -- I won't go down that rabbit hole here today. I always have the knack of doing that, so I'll stay away from that. But it really does have promise. And while we can be producing power, we can be sequestering the carbon, and we can be using the natural resource that really is a benefit to the country.

We need the advancement of lower emissions, electrification, and other sectors. Our Exelon utilities in our competitive arm are very engaged in analyzing where we can help in the electrification on the demand side. If it's converting the large motors in energy sources on the harbor, the bay in Philadelphia to electric, which is gigawatts of load off of diesel onto electricity, and that electricity is cleaner than the emissions of the diesel, we need to be helping in that. We think the transportation sector is very critical right now on the reduction of the carbon emitting sources and other gases. Our investment, our standup investment in electric bus company, Proterra, who is now coming out with great production of buses, has been key for us. We have stood up an organization to help our customers understand the details of what's it like to transition over to an electric vehicle. Not many dealers at the auto dealerships have been trained on that. And so helping facilitate the chargers being installed in their houses or help facilitate answering questions, has been a big part of it.

The world is changing in terms of awareness. There is one area of the country that we're not seeing the awareness and that's here in D.C. But our customers in our -- not the City of D.C. -- I want to correct that one. (Laughter) I see one very

important person back there -- but our government. And getting energy and environmental policy merged is critical. You know, we're seeing our customers across the board demand this from us. You consider what's come out of the most compelling IPCC report and then you see big companies like Google saying, hey, we're going to 24/7 clean. You want to be our supplier, you better be 24/7 clean. And that's what we're pushing for.

I discussed the op-ed we just came out with the MacArthur Foundation. That was critical in having a funder of the environmental organizations understand there's a transition that we need, there's a time we need, and there's a place for nuclear as we get the other technologies along. We see states out really pushing this hard. California 100 percent by 2045, the carbon tax initiative in Washington, their own initiatives here in D.C. that local utilities is supporting are critical. Our customers, residential -- and we've done the survey, a deep survey of our customer base using a more scientific methodology. Having reliability, having economic power, that's table stakes. That's not what they're worried about. They're depending on us to do that. They're number one need for us is as a company, especially our large C&I customers, is to deliver them low cost clean power and want us to be a leader as a company in the communities. So if D.C. -- I shouldn't use the word D.C. -- if our federal government isn't coming along -- I'll catch on (laughter) -- but if our federal government is going to lead, our customers and our communities are. And if we're going to be a relevant supplier of energy in the future, we understand the model, do what your customers want and do it in a safe, effective, clean methodology.

So that's where I would end it, David, just to open up and from where myself, by board, and all our company and our customers believe.

MR. VICTOR: All right. Thank you very much. So we're going to have a

fireside chat for half an hour or so and then I'm going to put it open to all of you to have questions.

You talked about a lot of different things and I'm keen to talk about the future of the industry. But let's start where you ended, which is around the situation around climate policy. This is not the first time that the federal government has been decoupled from what the rest of the country wants. So help us understand what the pathway is going forward. Your company is part of a group of companies that are now pushing for the so-called Baker-Schultz plan, which is the idea of a carbon tax and then give a dividend back to the American tax payer from that carbon tax. You're the only utility that's in that group. Is that the right way for thinking about federal policy? The current President I don't think is thrilled about carbon taxes, so when should we expect to see political progress on that?

MR. CRANE: We know we're just one small company in a large country. But we believe that coalitions of companies, public, private coalitions coming together can drive and make change. The climate leadership organization that we have joined, we are the first utility, but I would expect other utilities to come along. Many of the utilities have made just as aggressive commitments, if you're talking about southern company or AEP, and the California utilities, they all know what their customers want and they're committed to it. But you're getting companies now like Exxon coming to the table and saying, look, we get it, we know what to do. So what works in Washington is when you get enough voices that are helping support the election of the individuals, the stakeholders. They're hearing from their constituents is going to be critical.

We can't make false promises to parts of the country that we're going to make a fossil fuel cool again. What we have to do is worry about what this is going to do to the whole country. And so I think it's going to be around coalitions. I think as

companies come together, like ours, we need to be focused on what is the message that we can provide with a much larger voice by 2020 and try to make those changes.

Our belief is it should be market based. I believe when we start selecting technologies, we're out fighting against each other, clean or zero emitting technologies. We were against the PTC. Well, people thought that meant we were against the --

MR. VICTOR: The Production Tax Credit mainly for wind power.

MR. CRANE: The Production Tax Credit for wind. And so we got a black eye because people thought we were against wind. No, we want a market based solution -- who's going to provide the most zero carbon emitting sources. So let's get together and figure out how to do it. We've watched the competitiveness of solar come down through the manufacturing process. You know, let's figure out how to design it around that. If electrification of transportation can reward in lower tax and lower cost to those consumers, that's a better thing.

So we think that's the approach and that's what we're going to be putting our money and time behind.

MR. VICTOR: Help us understand a little bit about how big the deal needs to be. There's the core elements, a carbon tax and then a dividend, a refund. Some companies, oil companies, are looking to have some kind of waiver for liability lawsuits connected to this. Some people think that it would be very important to have job retraining programs as part of building the bigger political tent. You suggested in passing that maybe some tax reform that removes the direct subsidies just for some renewables. Solar and wind might be part of that.

How big does the tent need to be in order to get the politics to line up for a carbon tax?

MR. CRANE: We need to show all that it's to their benefit. We need to

make sure that we take as much of the commercial benefits to the individual technologies or companies out of it. We need to make sure the commercial side is adequately compensated for the investment they make so they will make the investment. But it has to be shown that it's a balanced win-win for all.

I think unfortunately we're still having the debate, is the climate changing. I can tell you as an operator of utilities, the climate is changing. (Applause) As the storms come through and the velocity of the storms come though -- thanks.

MR. VICTOR: Only in D.C. can one be applauded for saying the climate is changing. (Laughter)

MR. CRANE: Well, I've got to tell you we've got customers in all the service territories that we serve that believe the climate is changing and that, as I said, they believe that we have to be part of the solution of that in an economic way. But, you know, I think it's just imperative that we build the tent big enough, we make the story known, we take it away from being what has become just a polarizing partisan bickering to a recognition. You can talk to both sides of the aisle that say I can't really come out to say I'm pro nuclear, but I know we need it for a while. You can talk to the other side of the aisle that says this is hocus pocus and there's no such thing as climate change, that say, yeah, I know we need nuclear, but I really can't say for what reason. I can say maybe for jobs, but I can't say for the environment.

So I think our elected officials have to hear the voices of the nation in pushing on it. And as more states drive this, hopefully that will bring them along.

MR. VICTOR: So in the absence of federal policy in this area, or a carbon tax -- a significant federal policy -- right now your company and others are engaged in a lot of what might be called second best activities, getting incentives to preserve the value of nuclear plants and other low emission sources. In Illinois you have

these zero emission credits, you have something similar in New Jersey, New York, some political efforts in Pennsylvania, some other places. Is that the kind of world that we're going into where in the absence of a federal policy we're just going to have a whole bunch of these second best -- almost like bailing wire solutions? How far can that go before it really starts to get into the way of the markets?

MR. CRANE: It's a bandaid. You know, a company that said do not subsidize individual technologies or reward them in this methodology for the social benefit of the deferred carbon, we had to go in that direction or we were going to be shutting down a lot of nuclear plants a whole lot faster.

I'll be the first one to tell you some of the nuclear plants are small, uneconomic, and they won't make it. And they probably shouldn't make it. It's not save every one. But understand right now there's a company in Ohio that's going through a bankruptcy that if those four nuclear reactors shut down that are non economic right now, every dollar that's invested in renewable energy credits in PJM will be forthwith not. It will totally wipe away the benefit because of the avoided carbon that those reactors that are producing power with right now. So it will be a crime to go backwards.

You know, you can use some countries that have done fantastic investments in renewables and now they're having to get stability transmission in place and their electric costs are at the highest, their nuclear plants are shut down, but oh, guess what, reliability is being maintained by the dirtiest source, which is lignite. So you're not seeing the reduction in carbon that they expected because they went after a technology and not a market based solution.

So I think that what we're doing right now is band aids. What we need to do is either a regional or a national fix. We've been talking with the regional operators, the ISOs, you can PJM set up a marketplace for this, can New England ISO set up a

marketplace for it. New York has been in conversations recently about putting it into its market pricing. That would be a better fix than trying to do it on an individual technology. The most beneficial would be federal, but what we've got now just is buying us time. And time is running out on many of these assets and we will end up going backwards. Our dependency will grow higher on carbon emitting sources than go lower.

MR. VICTOR: So when you look to the future -- you mentioned the company is in the process right now of looking at the world out to 2050 and big reductions in emissions, do you expect that if we develop a federal carbon tax and a strategy for reducing emissions in this country, does that slow and stop the retirements of nuclear plants, or are you actually expecting to see new plants built?

MR. CRANE: You know, I think the first action will slow. There's a couple of plants under construction. We get to read about them. They're very expensive. And in a competitive market, in the current market design, I don't see new plants coming on. We support the development of the new technologies and we think it's imperative. We think our country is losing an international advantage by the retreat we're making, but we can't expect our customers to pay the costs or we can't expect our shareholders to lose the money on developing new ones in our market designs that we have now. Other parts of the country have different market designs.

I will tell you that in 2005 we initiated an effort in Exelon to potentially build two new reactors in the State of Texas. At the time natural gas was \$8 and the projection was going to \$13 an MMBTU, we were modeling in like a \$25 carbon tax. You could build a reactor. If you're sitting here trading 2019 gas at \$2.90 an MMBTU, a carbon tax to cover that would be in the hundreds -- \$3-400. That's a very tough one to do. Our bet for our company is advancing technologies around storage and sequestering technologies. We think we can do that much more economically.

I'm the biggest nuclear proponent in -- you know, one of the biggest nuclear proponents in this country, but it is not under this market design and it's not under what these costs are. There's a reactor design new scale that is a modular reactor, shorter capital cycle to put the reactors in. Under the right market design, under the right system design, these smaller distributed reactors may be a very critical source of dependent based load power going forward if we cannot get to the storage chemistry. Is there a life beyond lithium and ion or is there a perfection of the anode and the diode within the lithium and ion? I mean a lot of things are going on by smart people, not by me, that we just write the checks and they do the work.

MR. VICTOR: It's a good business model.

MR. CRANE: Yeah, yeah, it's helpful. But I think that's the path.

MR. VICTOR: So let's talk about natural gas. Right now with nuclear under tremendous stress, some plants closing -- you mentioned First Energy going through bankruptcy -- you've just closed a plant I think last month in New Jersey, you've announced you're going to close one in Pennsylvania, Three Mile Island Unit 1, next year -- with nuclear being squeezed out, with more renewables coming in, gas has really become the default option. You have 20 or 30 percent of your own generation fleet as gas.

How should we think about the question of whether the country is now becoming overly depending upon gas? In some sense the new energy security problem is excessive dependence on natural gas and problems that might be creating for reliability of the grid.

MR. CRANE: Yeah. We believe that natural gas, that in the price and the abundance of natural gas in the country is definitely an economic benefit. What we have to do is work on the environmental attributes. We just put on two brand new

combined cycle gas generation units in Texas. They're the most efficient in design, they have a heat rate, a thermal efficiency that allows us to produce more electricity with less consumption of natural gas. So that's better for the environment than say some of the coal plants that we shut down that were unscrubbed and had higher emissions. We've gotten out of the coal business altogether. Our coal plants were built in the Eisenhower era and they weren't efficient, they couldn't compete.

So, you know, you're seeing an advantage already with the reduction of our sector in the use of natural gas. Our problem with the security issue of natural gas is the natural gas day and the electric day are not organized. And the analysis that we're asking for as a company and as an industry is give us what's the design basis threat of the gas system to the electric system, and how do we create the redundancy that's required to ensure the reliability. New England, we have gas units in New England, we supply a good part of the load in New England. Our three gas units are supplied by LNG facility right there at the plant because we cannot get pipelines into New England because of the push back on that.

Now, we got close to losing -- if we had many more cold days last winter in New England, we would not have been able to provide power. We were running low on LNG. It was all over the paper, the LNG was coming from Russia, but we were burning oil. And it was going to take 195 tractor trailer loads of oil a day coming through a congested part just outside of Boston to keep the fuel going. So what did we do? We shut down a nuclear plant, we're shutting down another nuclear plant, we're not allowing transmission to come in to New England from a Canadian hydro, we're throwing arrows at those suppliers at every angle, and there's already talk if you lose -- and it came out from the ISO itself -- if we lose one gas supply line going into New England, next winter we're in a very critical period. So instead of us coming together and figuring out the

short-term plan, maybe we need to get some pipelines in in the meantime. Then the longer-term plan of what do we do on affordable environmentally sensitive technologies, have that transition. I think it's imperative.

The analysis of how many natural gas plants are tied to the northeast corridors of gas transmission lines need to be fully evaluated. And then the redundancy. When we submit to FRC and to NRC the reliability of our system and the design of the system, or to our state regulators, there's a design called an N-minus-1, so if we lose the 765 going out of Illinois --

MR. VICTOR: That's a transmission line.

MR. CRANE: The transmission line, yeah. You'll have to help me.

MR. VICTOR: I'll translate, yeah.

MR. CRANE: Yeah. I'll get going too. I can go really deep quick.

MR. VICTOR: Don't.

MR. CRANE: Thank you. I got Maggie looking at me too. But if we lose that, we know that there is adequate transmission capacity on alternate lines that can keep it going.

In some areas of criticality, we have an n-minus-2, which means we have two alternate paths that we can depend on so we know that electricity can flow. We need to combine that knowledge of gas flow to generate the electricity, to make sure that we can transmit the electricity in the safest most reliable way. And I think that's the conversation you're hearing from the DoD, Homeland Security, and the DoE right now -- how do we come up with the resiliency design.

MR. VICTOR: So you've said many times today and in many other speeches, you talk about a lot about resiliency and reliability. Other people in the industry do the same thing. The warning signs are there, and yet it seems like we don't

actually do it.

So are we now headed to a world -- maybe especially in the northeast where there are these bottlenecks in the natural gas system and natural gas when it's very cold gets used for other purposes, like home heating -- are we headed into a world where soon we're going to see huge problems of reliability of the grid?

MR. CRANE: I truly hope not. And the reason is we're not going to be in a position to say, I told you so. Nobody wins by being able to step back and say, hey, I told you last year you're going to lose it. We're responsible to deliver the energy, either through the utilities that operate or through the generating companies that produce power. We are fighting hard as an industry, as a sector, as the ISOs, to inform we have to do something better and we have to do something different.

If we were to sit back and take the opinion the only way to fix New England is if New England lost an energy source, that would not be a very productive way to run a company. And so we're not doing it. What we're trying to do in the regulatory space is make sure we can keep that LNG facility running and those gas plants reliable and to explain that we're burning a whole lot of oil in the winter when we should be bringing in Canadian hydro at that period of time through a transmission line that goes through an area of the country people don't want to see a transmission line. But they do want their lights on. So we have to continue to communicate the necessity or figure out how to facilitate doing that.

Yeah, I'd be the last one to say we're not going to get this fixed until we have a disaster. I don't want a disaster because we'll be all at fault if we have the disaster.

MR. VICTOR: That scenario played out in the nuclear industry after Three Mile Island and the industry got together, created the organization for which you're

chairman, the Institute for Nuclear Power Operators. Does something like that need to happen inside the industry where the industries better organize so that a failure in any part of the industry is not harming the reputation of the industry?

MR. CRANE: We've done a lot. There's an organization, the American Transmission Association, that's looking at driving greater standards around transmission and reliability, significant work in sharing around cyber. We have great coordination with the federal government through the electric sector committees where we sit once a quarter, publicly traded co-ops, munis, CEOs across the table from our lead counterparts at the Department of Energy, Department of Defense, FBI, cyber command, and we're talking about the physical and cyber security requirements. So the integrity of the system is under review, and what we can learn from, we do that sharing.

The natural gas AGA is really going to take on what happened in Andover, Massachusetts, and after this analysis understand what the --

MR. VICTOR: This is where there was an over pressure on the gas lines and a lot of the houses blew up.

MR. CRANE: Yes. A lot of houses blew up and it was an unfortunate issue. There was a design issue around it; there was a construction competency issue around it, from preliminary information. The National Transportation Safety Board will come out with their report, but what we see is, was it preventable -- potentially. And what we can do to share that information, we'll share it.

After Three Mile Island the industry learned very quickly we didn't know how to communicate during a disaster. We weren't training our operators for the most severe events and we didn't have the most resilient designs. So we went through massive modifications to the systems. We now accredit through an independent body the training programs of all the reactor operators across the country. They're held to the

highest standards. We're constantly drilling with the state, local, federal officials on events, we're having more and more design reviews to not only have the operation resiliency, the mechanical integrity, the design -- learning from Fukushima, learning from other events across the world, we're only as good as our weakest link. And I think we have to head that way within our gas system also to be able to provide that learning.

The one thing about our sector is in the utility side, the wire side, and part of the generation, we don't compete. We're giving the right to operate in a monopoly. That right is overseen by our regulators to make sure that we're doing safe, reliable, affordable, and clean. But where we do compete, say in our reactors against another competitor operator reactor, we don't compete on safety standards. We get our operators together, we train together, we want every reactor to operate safely, like we want every natural gas system to operate safely. We're only as good as our weakest link. And so when somebody starts to falter in the quality of operations, we come to the rescue. We have INPO there, they monitor the performance, they will go into a boardroom and they'll tell a CEO and a chairman and the board if their baby is ugly and what they have to do and offer the support to improve the operations.

MR. VICTOR: Good bedside manner. (Laughter)

MR. CRANE: Yeah, it is. I could have used a better term I guess.

(Laughter)

MR. VICTOR: Don't worry, you're on the record, so I'm sure someone will have a headline about it tomorrow.

MR. CRANE: And I see the cameras. That one's going to be the sound bite. (Laughter)

MR. VICTOR: Let's talk a little bit about the regulated nature of big chunks of this business. Almost everything you described today in your prepared

remarks is very capital intensive. Investing in new kinds of power plants, investing in new transmission lines. As the grid goes to more renewables, we know that we're going to need more transmission capabilities -- that's expensive to provide -- infrastructure for electric vehicles, even getting ready for a two degree world is going to require, as you said, hardening the grid. That's expensive as well.

The tradition business model has been we deploy massive amounts of capital in the industry and then there are stable market rules and regulated returns, and the return is sufficient that companies will go off and do this. It seems like in every corner the business model is being turned upside down right now. Demand is no longer growing, it's flat, many markets now allow new entrants to come in who don't necessarily have to pay all of the costs of the previous system.

Are you worried about the future of the business model and companies basically stopping investing? Because this is a really capital intensive industry.

MR. CRANE: You know, as I talk with my peers and talk within our company, what's happened is the words "disruptive technologies" is taken out of our vernacular. Six, seven years ago CEO would sit around and talk about we've got this disruptive technology coming our way and how do we fight it. As a sector for decades we've been known to throw the body block at anything that is going to change our life. We were very comfortable up to a decade ago calling our customers rate payers. And so, okay, they're rate payers, we just send them the bill and they're going to pay it. Well, the world has changed. And any company that's not changing with that world is really going to fall behind.

Now, we're working very hard within each one of our regulatory jurisdictions to define what each one wants, the utility of the future. Do you want two-way flows on a distribution system that was designed for a single-way flow? Well, if you want

two-way flows, we've got to get out there and figure out how to support that, not that --

MR. VICTOR: The two-way flows are important because people may want to have solar on their rooftop or small nuclear reactor in the backyard. (Laughter)

MR. CRANE: We hope not. We hope not, but definitely distributed generation is what our customers want and it's what our stakeholders want us to facilitate. Our job is not to say no, but to say okay, right now we can tell you here's the best place to go market that because the system can afford it, and do the design that each one of our systems. Where do we have to upgrade to further support or what do we have to do to employ the technology that allows two-way flows. So the system was designed that you're dealing with today many years ago. Now, upgrades have been done and poles have been changed and wires have been changed and programs to underground, things like that have been done, but it was a central station methodology thought process running down high voltage transmissions, hitting transformers to go into distribution systems, and on paper were calculations on the size of the line and the amount of the load. And what our engineers would do is monitor, okay, we got 10 more houses coming in, here's where we might have to upgrade.

Then came the smart meter. Then the smart meter started to give us truly what the loads were. We didn't know your power was out until you picked up the phone and called us, and then our operations folks would start to aggregate how many phone calls did we get from this neighborhood, and then we'd figure out how many trucks do we have to send. And then we'd send the trucks up and down the road and even after the power is restored we don't know that because we don't have anything unless they call us. So the one location in our company we don't have smart meters we've done started the reverse calling. We call a customer and say we understand your power is out, we understand this is how much time we think, we call them, we say the truck's rolling, and

then we'll call before we roll the truck to say is your power back on, because we don't know. But most of our customers we know that. But we know the flows, we know the loads, we know how we have to make the system more robust. We have to sit with the stakeholders that are telling us we want you to do this, and we have to show them here's the price tag, here's how we think we can do this. If you agree, we'll go get this done and the customers and the stakeholders will be provided with what they should be provided with, and that's what they want.

Now, sometimes it is cost prohibitive and we have to show that we just can't get there under the current system. There's reliability issues, there's resiliency issues. As we digitize our systems to make this more flexible, we're introducing new risk. So making sure we have the right encoding of our digital technology, making sure we have the right cyber overview of our operations that we can detect intrusions, mitigate, isolate, and fix as quick as possible is an imperative. If you can imagine the responsibilities we have. If this town was to go out for how long, what would be not only the commercial issue but then the social unrest? If the west side of Chicago goes out -- I was talking to Mayor Mitch Landrieu the other day. He had a man -- a really nice conversation around diversity and inclusion with all our VPs, but we were talking at lunch and he said, look, you've got 72 hours. I can tell you from Katrina, if you don't have it back within 72 hours, all heck -- not the word he used -- but all heck is going to break loose. And so the responsibilities on us have become much stronger to analyze and invest in that system. But you've got to let the stakeholders know why you're doing it before you do it and get the buy in.

MR. VICTOR: So just a couple of more questions and then I'm going to put it out to you folks to ask questions.

Do you see in this world of all of these new technologies and digitization

of the power grid, do you see that's a world where the incumbent utilities -- and you operate many of them -- is that a world where those utilities thrive or do they have many more threats to their core business?

MR. CRANE: It's one where we should be able to thrive. If we are out and we are defining the future with our stakeholders and defining it to do it in the most efficient way, we should be able to thrive. If somebody has got a better model and they can do it better, cheaper, faster for the economy, they should have the opportunity to show that. We have a lot of investment, we have a lot of sunk investment, but we can't live on the sunk investment. We will invest at the Exelon utilities in the next five years \$28 billion. Part of that is resiliency, part of it's reliability, part of it's expansion of the system to meet the needs of the customers. That's going to be a 30 year recovery on most of that, you know, from a depreciation standpoint.

So, sure, we should have the opportunity to have a seat at the table in the design. What we're finding in some cases, partnerships are very critical, especially in the world of digitization, in the world of energy efficiency, in the world of distributed generation. We're not going to be the most cost efficient individual company to put the solar panel on the roof. But if there's a control element, an inverter that can better help us operate that system, we should partner with that solar provider working through our regulators to be allowed and be able to do that. So let us have a seat at the table. If we don't bring you the ideas that you want to see fixed, then somebody else should be able to get it, but us be willing to partner with people and kind of adjust the model I think is also a critical way to go forward.

MR. VICTOR: One last question from me. You mentioned earlier that you're concerned that the country is losing its leadership and its edge because of our failure to preserve our nuclear fleet, let alone build new reactors. It seems like when you

look at a lot of other areas the same story is unfolding. You mentioned 765,000 volt power lines -- those are our maximum voltage power lines in this country. I was in China last week in part to visit the state grid. They're building 33 million volt lines, moving massive amounts of power long distances. Other countries are doing lots of innovative things. Is this like a national crisis around competitiveness and our position in the world? And what do we do about it?

MR. CRANE: Well, you know, the electrical transmission and distribution industry has become very international if you're dealing with Siemens or if you're dealing with Hitachi or Toshiba. We still have some manufacturers in the country that are providing that, but the generation technology, the nuclear technology, the export of nuclear technology is dominated currently by the Russians into the emerging countries. You're seeing some of the Korean activity, at least in some locations. But the Chinese, who have acquired the U.S. technologies through the purchase of the technologies will now be marketing them. So if you look at the development of Africa, if you look at the development of other emerging countries, and having no control any longer over the technology or the deployment of the technology, we've lost a huge technological and national security advantage. There are many top generals and admirals that are fighting for this, you know, here in Washington to be able to have a seat at the table as the technology is deployed.

I know today from being on the governing board of the World Association of Nuclear Operators that we do pre-startup checks in almost every country on new reactors coming in. The Chinese reactors are being built with high qualities, their training programs are being assessed internationally. So I'm not afraid that the technology is not sound or it's not being deployed with the correct intent, what I'm afraid of is our leadership position has been diminished and we need to recognize that.

We have two domestic suppliers of nuclear technologies right now, General Electric and Westinghouse. Westinghouse went through a bankruptcy and is owned by a Canadian private equity firm right now. General Electric has continued to do some design work on fuel and reactors, but has not been competitive in the bidding of technologies going out. Some of us are providing services to other countries around rating for operations and operational services. We have a team in the UK working with the Japanese on a project there. We have individuals in the UAE assisting with putting in operating and training programs. But having companies with the capability to provide that, our knowledge, our deep knowledge in operating history and safety standards I think is an imperative for our own national security going forward.

MR. VICTOR: All right. Thank you very much. I'm going to open it up for questions. If you raise your hand you will get a microphone. Why don't we start right in the back there since the microphone is already in the back? Just to your right. Behind you, yes. Why don't you say what your name is and then your question? If you could keep it kind of brief because it looks like there are a lot of questions.

MS. THORNDIKE: Sure. Hi, my name is Camila Thorndike and I've had the pleasure of coordinating the coalition here in D.C. that's working for the clean energy policies that you mentioned. And we're glad to hear that Pepco Exelon is in support of some of those measures. But I would I guess take issue, or have a question around the additionality problem, because here we don't have nuclear, we would actually be asking rate payers to bailout the existing nuclear facilities by allowing for zero emission credits, or some kind of mechanism rather than incentivizing additional new solar, wind development. So I'm hoping you can clarify your position on that.

MR. CRANE: Yes. It's advantageous to use the word "bailout" in nuclear, but the word bailout is not in there for solar or for wind. Just in a statement that

people make. It's not a bailout. We cannot afford to run plants that lose \$800 million over a seven year period. In the State of Illinois alone 60 percent of the power that's being produced in Illinois is carbon free, 90 percent of that is nuclear. If the nuclear is not getting compensated for the social benefit of carbon and we're losing money, we're going to go backwards from an environmental standpoint. If your goal is truly to lower the carbon footprint, nuclear needs to be part of the transition. Many environmental groups are modeling that. The basis for it in solar, wind, and other non admitting sources, is the social benefit. Nuclear has the same social benefit. So you compensate it for its reliability. It runs 24/7. It doesn't have to have the wind blowing or the sun shining to provide power. During the polar vortex the nuclear plants ran straight through. There was not a problem with one of them. Coal piles froze up, natural gas pressures got too low, wind wasn't blowing, and the sun wasn't out. So it provided a level of reliability and they should be compensated for that. It provided a level of environmental impact. If you look at the offset -- because what would have been running in that period is primarily coal and gas. So if you look at the social benefit of the offset is all we're saying.

Now, if people don't want nuclear, they're saying, okay, we're going to try to figure this out like Germany did and our carbon is going to go up. Why can't we work together? Instead of saying it's a bailout, saying we understand the social benefits of it, we're paying for the social benefits on the intermittent sources, and then figure out how to get to the future.

The thought process that we need to just shut them all down and stop paying for them, that it's a bailout, is in our mind the incorrect way to communicate it. The way to communicate it is it's a gap source. We don't want our customers to have to pay any more than they should. But our customers are telling us they also want it to be clean. And we can't do that on a baseline product that runs 24/7 without either a higher

dependency on fossil based fuels or a lower reliability element.

MR. VICTOR: Next question right here. Sir? You can even stand up if you want to, or not; your choice.

MR. BEHR: Thank you. Pete Behr with *E&E News*. You've made an argument for supporting the uneconomic nuclear plants based on their carbon, their zero carbon, their climate value. The Trump Administration has tried to come up with a policy for supporting noneconomic coal plants based really on a national security argument, claiming that these are essential to the grid's resilience. Is there a well founded national security argument for supporting uneconomic coal plants since the carbon argument doesn't work for them?

MR. CRANE: You know, what has to happen from the federal government to make that clearly understood is the resiliency design. So what we have to understand, and what we've been asking for as a company and an industry, is what is the design basis threat. I can tell you the design basis threat that we design and build and protect a nuclear plant at right now, based off of the insight from the NRC and the Department of Defense and the continuing threat assessments that are being done.

What we don't know right now is what is the threat assessment in the design basis that we need to keep firm fixed fuel plants alive as we understand the relationship between the natural gas transmission system and what needs to be available to run through whatever scenario. So, you know, I think what I understand -- and I'm not in the inner workings and it's a conversation between the White House and the Department of Energy -- what the basis of their conversation is. What I've heard is that it's a short-term gap to save uneconomic assets as they can do this design, but truly to be able to say that's the case, we need a design basis threat and we need to know what we're doing now.

The world has changed; 15-10 years ago we were not told that we needed to protect our customers against enemies of the state. So is there a cyber threat and standard that has clearly been defined that we're to design our system and to look at the redundancy of our system based off of? That needs to be known. Is there a dependency on a single transmission or multiple transmission lines of natural gas that we should know how to protect? Or if they are made unavailable, either through a cyber or physical attack, how do we keep the grid up? Nobody is going to want to care about what decisions were made when half the country loses power because of some threat.

So we're not the ones qualified to come up with the threat scenario or the design basis to support that threat. We need to intel from the government to come up with it and then the system operators, if it's PJM or New England ISO, New York ISO, or Cal ISO, wherever it is, can know how to design their system, what coal plants have a vulnerability and should stay around, what nuclear plants have a vulnerability from the resiliency and the environmental standpoint to stay around.

What happened to us is we were pushing an issue because we're technology fighting technology versus outcome. We were pushing the dependency and the need to save the nuclear plants through some market based reform that recognized they're environmental. At the same time, there were coal plants in trouble and there were employment concerns about the feedstock for those coal plants. And so they kind of got merged together and it's muddied the water. But I think for both technologies, clearly, tell us what the design basis is, allow the system designers to design it, and then the market can figure out what stays or what doesn't stay.

But I don't know what's going on in the inner workings.

MR. VICTOR: The next question is here. Just as the microphone is moving over, let me just press you very quickly. You mentioned this coordinating

committee was set up a few years ago to bring together intelligence agencies and so on. There have been new claims made about the risks to the grid from coal plant closures, concerns about nuclear plants being closed, and so on. When you look at the grid overall, is it getting more reliable or less reliable, or do we have actually no idea what the nature of the threat is?

MR. CRANE: No, I think we do. I think from a reliability standpoint we have an idea at each ISO that from --

MR. VICTOR: Each of the regional system operators?

MR. CRANE: Regional system operators, where the vulnerabilities are. Some are in a very robust condition and some need some work. And it's been openly discussed. If you're New England ISO, the ISO itself is just publicly announced. We could be in trouble if we lose a gas line coming into this winter. If you're Texas the market design doesn't compensate for capacity. We all went into this summer down in Texas really making sure our plants were running and we weren't the cause of localized brown outs or black outs or any situation like that. So does the market design in Texas need to be reevaluated for the reliance? I feel very good right now about the reliability in today's world in PJM. But the world is changing.

MR. VICTOR: The market in the northeast, the (inaudible).

MR. CRANE: Right. That goes from New Jersey down to Virginia, all the way through Pennsylvania, Ohio, a little bit of Indiana, and all of northern Illinois. So it's a well founded, well engineered system, but their mandate right now is only reliability. They think they're okay with some of these coal plants shutting down, but they haven't done a resiliency review that we need. And I think they're underway trying to figure out what that resiliency review should look like when we need more of the defense telling us what it looks like.

QUESTIONER: Hi, Chris. I'm Jay. I represent the Tata Group. We are 240 billion group. We serve about 12 million customers daily in Mumbai, 11,000 megawatts of power. My question to you is what do you think about digital twin? We have created digital twin for Pepco in Tokyo as well as Mitsubishi for the rest of Japan, and they have been able to save 300 million in Pepco, 350 million in Mitsubishi. Apart from adding all the safety, reliability, resiliency, in fact even the cyber threat and intelligence can be monitored through our digital twin.

MR. CRANE: Distal twin?

QUESTIONER: Digital twin of the power plant, digital twin of the generator.

MR. CRANE: I'm not familiar with that.

MR. VICTOR: You mean digital twin.

QUESTIONER: Yeah, it's a digital twin.

MR. CRANE: I'm sorry. I'm sorry, digital twin. Digital redundancy?

QUESTIONER: So you could actually create complete digital (inaudible) of the power plant itself which can be monitored remotely through IT/OT integration, et cetera. And it delivers benefit.

MR. VICTOR: Do you want to talk briefly about -- maybe less on the digital twin directly and more on the digitization affecting the capacity to make the system more reliable?

MR. CRANE: Yes. I think having much more digital information coming across the system has helped us significantly. The energy efficiency to some of what you're saying, we now know the voltage is on the line, we can cut back, cut down on our voltage levels and still be delivering the reliability and the power at a much lower cost having that digital capability. So it has been much more effective as we go forward

around energy efficiency.

The digital monitoring that we have on our power plants now -- on our new ones -- a massive amount of digital data that we have on our system has required us to hire data scientists. And whoever thought a utility was going to have a data scientist. We have scours of data scientists helping us with just those issues.

MR. VICTOR: That means that even if you aren't a data scientist, he wants you to say you're a data scientist when you're looking for a job. (Laughter)

MR. CRANE: Yeah.

MR. VICTOR: Next question right there.

QUESTIONER: Hi, Karl Golivan. I'm no fan of petroleum. Can't wait to have an electric car. My question comes out of reading a book sometime ago by F. William Engdahl titled "Myths, Lies, and Oil Wars", and it prompted some back of the envelope calculations that the volume of the earth under our feet is about 260 billion cubic miles, and the volume of all the oil/petroleum used in the last 150 years is about 50 cubic miles. So it's hard to believe that the earth isn't resilient enough in its capability to moderate the impact of that.

So I am a skeptic of the carbon argument. I would ask you what is the single best scientific study you point people to who question the science versus politics of carbon?

MR. CRANE: You know, I think the one that our folks have used the most is the IPCC study and also the work that we get from EPRI that has come out. We have a good association with MIT working around that in the technologies. It would be easy for us to say as a company that somebody else is going to have to decide, somebody else is going to have to justify it or not justify it.

We believe as a company, and I believe as an individual, we can't afford

to wait. I can tell you from the storm patterns that we're dealing with, I can tell you from the dispatch of our utility workers to the south, to Texas to Florida, to South Carolina and the flooding, the environment is changing. The wind speeds that we designed our systems to withstand are not the wind speeds we're seeing. You go back to the Allstate commercial that the 1 in 200 year storms, we've had how many of them in the last year. From our system impact we are seeing a change. Is it man-made totally? I don't know that. Is there some natural effect? I don't know that. But I know I'm responsible to provide safe, reliable, affordable, and clean energy. Our customers want it, our system is demanding resiliency, and so we think we need to be part of it. Just as Exxon does, it takes that oil out of the ground, just as many others do.

So I'm not a climate scientist, but I am a realist and I can see and our company can see and our technical experts can see the world is changing. So we're not going to deny it. We're going to try to get out in front of it.

MR. VICTOR: Time for one more question -- maybe two. Back in the back corner there with the blue shirt. Oh, I'm sorry, we've got our microphones in the wrong spots, but it will be to you in just a moment. We have time maybe for two if we're efficient, but certainly one.

QUESTIONER: Hi. You've talked about nuclear energy as being clean or carbon free, but I'm concerned about the massive amount of fossil fuels that are required to store, transport, and protect the spent nuclear fuel. Here in D.C., which is the city, not the federal government, which is where I live, we have a clean energy bill that we want to get through. We want to incentivize the building of new renewable energy sources. And we're concerned about the so called zero emissions credits. I don't feel like it helps the climate and interferes with the integrity of the clean energy bill.

So if we're not incentivizing the construction of new renewable energy,

when are we going to be able to stop forcing rate payers to spend money on these aging nuclear plants that you've talked about are losing money?

MR. VICTOR: Do you want to talk briefly about this? I know you commented on the first question.

MR. CRANE: I think I'm going to go back to my first answer. If you really care about carbon, if that's what you're for, if you're about technologies, you're about technologies. What I'm talking to is if you're about the environment. And right now the amount of generation, the massive amount of electrons 24/7 that are being produced by nuclear plants, far exceeds the intermittent sources of the renewables. We believe there are technologies coming down the road that can optimize those renewables. That's why we're making investments in large scale solar. We're trying to find that next source of storage beyond lithium ion or the perfection of lithium ion. If you're in the State of Illinois and the wind is not blowing and the sun is not out for most of the winter, which happens quite a bit --

MR. CRANE: Not to say disparaging things about Illinois.

MR. VICTOR: Not to say -- lived there, paid a lot of taxes there. But we don't have a source that can provide that. And if you do believe about the environment and carbon, you'd have to understand the dynamics of the grid. When the wind is not blowing and the sun is not shining, without very large scale long-term storage -- much more hydro electric, much more battery storage, much more certainty of getting that in, we don't have a reliable grid or you're using much more fossil fuels.

So the negativity around the ZEC is a negativity around the technology. And if you don't like the technology, you don't like the technology. It's all about the outcome right now. One of the downsides of the technology that we clearly understand and recognize is the spent fuel and the long-term disposition of the spent fuel.

Volumetrically it is not big. Toxicity it is big. We have put over almost \$30 billion into the federal coffers to help us take care of that. That was a law that was passed in '79. We own that, we need to be forthright about making sure the long-term repository or the interim storage is managed properly and we have to be on it. Right now storing fuel is not taking up a lot of fossil fuel, so I'm not understanding your comment there. It's a manufacturing process of cylinders that are loaded by electric cranes from the spent fuel pools onto a pad at the plant and they're sitting there. So we're not driving a lot of fossil trucks around transporting anything today.

But it goes back to what do you want? What's the outcome?

MR. VICTOR: Let me just ask you this as we close here, very briefly. Seems like the industry nonetheless has an image problem around the technology. You mentioned Google is going 24/7 all clean, but they're going 24/7 renewables clean. That's their vision of clean. Do you see a world maybe with small modular reactors when the Googles and the Apples, the Walmarts want to go all clean, are going clean with a blend that actively includes nuclear power?

MR. CRANE: It could if it's affordable. But we're looking at other technologies. One very promising technology to harness wind and solar is pressurized hydrogen. And so we're looking at a technology at Toshiba's research facility in Japan, last year took a team over, where during the day we're producing maximum amounts of solar, and if the demand isn't there we use the technologies to convert the water, store the hydrogen, and have a massive amount of stored hydrogen that can be utilized through fuel cells. The hydrogen fuel cells are zero emission. Toyota is going to the hydrogen fuel cell for their car of the future. They've given up on the electrical design. I think there are other designs and other technologies that are coming that we're watching very closely and investing into.

But if you picture a world where we do get to a hydrogen economy, which that was a study that was done a couple of decades ago. There is becoming more possibility of distributed hydrogen. We can't get to the point that we're mass producing hydrogen and distributing it through the old fossil lines, the oil lines. There's metallurgical problems with it, there's embrittlement problems, and I'm going down a rabbit hole again, I get it. (Laughter)

MR. VICTOR: I was just about to stop you, but you have a good internal corrective there.

MR. CRANE: But, no, there are other things. And we as a company and we as an industry are working for those. So we don't have to have picking one technology over the other, we can get to that renewable future. I don't see us getting to a total 100 percent distributed generation grid anytime soon. It's very expensive. But I do see distributed generation systems and micro grids being beneficial to society in certain locations that are fueled by hydrogen cells, they're fueled by other sources, so they can run when the whole system is down.

MR. VICTOR: Excellent. Well, please join me in thanking Chris Crane for a terrific discussion. (Applause)

MR. CRANE: Thanks for having me. I appreciate it.

MR. VICTOR: It's a pleasure.

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