

THE ASPEN INSTITUTE

ASPEN IDEAS FESTIVAL 2017

THE ROAD FROM PARIS: A CONVERSATION WITH THE FORMER
SECRETARY OF ENERGY

Doerr-Hosier Center, McNulty Room
Aspen, Colorado

Saturday, July 1, 2017

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SECRETARY OF ENERGY

(10:20 a.m.)

MS. JOHNSON: Hello everyone. Please take your seats so we can get started. I'm Tricia Johnson, I'm with the Aspen Institute and I'm happy to welcome you this morning to "The Road from Paris". I'd like to introduce Susan Tierney. She's one of the nation's leading energy analysts. She served in the Department of Energy under Bill Clinton. And among other things she currently chairs the DOE's, Electricity Advisory Committee. Please help me welcome Susan Tierney and Dr. Moniz.

(Applause)

MS. TIERNEY: Good morning everybody. Thank you for coming inside during this beautiful day. I just can't resist spending a couple of minutes introducing my colleague, Ernie Moniz. I am really happy to say that he is the best Department of Energy secretary that the nation has ever seen.

(Laughter)

MR. MONIZ: Thank you.

(Applause)

MS. TIERNEY: And especially --

MR. MONIZ: I really like Sue, you know, she's terrific.

MS. TIERNEY: We didn't practice this I promise you. Let me just tell you a few words about him. He is a particle physicist from Fall River, Massachusetts. I just spent 35 years in Massachusetts, so I kind of think of him as a homie.

MR. MONIZ: Uh-huh.

MS. TIERNEY: And from there -- he came from immigrant parents from the Azores. This will have a theme in just a moment. After an academic career Ernie has spent a lot of time both as a scholar, as someone who's been involved in a number of non-governmental organizations and then importantly in the federal government where he served

during two terms, both in the Office of Science and Technology at the Department of Energy in -- as an undersecretary, and then most recently as secretary of energy.

So I say that he's the best DOE secretary, because he's the whole package. You -- okay, you were the whole package. I still like to think of you as being there so I'm going to use the present tense if you don't mind. He has incredible domain expertise in the variety of subject matters that come at the Energy Department that's everything from high energy physics to solar power and dealing with nuclear weapons.

So he knows a variety of things, but probably most important he also knows institutional processes and systems in which humans interact and that's incredibly important at the Department of Energy, which is in effect a holding company that includes both national security, renewable energy, fossil energy, basic science and so Ernie brings all of that to bear.

And one of the things I admired about Ernie was that he was able to instill credibility and respect across both aisles when he served as secretary that came across during the nomination hearings for Secretary Perry how much people admired Ernie and hoped that there would be continuation of his legacy. And most importantly Ernie Moniz is the recipient of the Grand Cross of The Order of Prince Henry from the Portuguese government. So that Azores connection, I'm sure it wasn't the only thing that was to bear for that, but it's great to be part of sitting here with Ernie.

So let's begin. This session is called "The Road from Paris" and Ernie was critically involved in the road to Paris. So I'd like to hear Ernie's thoughts about what it means to have had a little bit of a derailment off of the road and what you think we can expect from continued progress even on that road without the Trump administration support?

MR. MONIZ: Okay. Well, thank you Sue, and certainly thank you for that completely over the top introduction. If I'd known I would prepare one for you as well. But also let me also just add one note since keeping track of all of those different DOE activities may be difficult the way to remember it is it's the department of weapons and windmills, corks and quagmires; that's the

summary of the department.

Now, in terms of the "Road from Paris" first of all, let me say what Paris was, because I think everyone naturally in thinking about Paris thinks about the Paris Agreement, which by definition was the last day of the Paris meeting in December 2015. But I also want to remind people at the first day of the Paris meeting a very important event happened as well and that was when the leaders of 20 countries with Bill Gates there representing 28 international investors launched something called "Mission Innovation."

The idea was that these 20 countries -- now it's grown -- would double the -- their governmental investments in clean energy innovation over a 5-year period. The important point was the Paris agreement said basically every country in the world developed economies, emerging economies, much less developed economies all understood the importance of pursuing a low carbon future and frankly took on, you know, they're not mandatory, but took on targets that are not so different among those classes of countries; a stark change from Kyoto in the 90s. And secondly that the innovation focus for the first time squarely put technology innovation at the center of the global solution. So those are both components that are important. That's the launching point now for what's happening now.

Unfortunately, the administration has put forward statements and proposals that are counter to both of those threads, which is another form of dissonance that I'll come to. So first of all, of course on June 1st the President announced the beginning of the process to withdraw from Kyoto. That is a process that will go until November of 2020, but that's little consolation, because the idea is in the intervening period, the administration will do nothing to advance towards the goals even though technically we will still be in the agreement until the end of the administration, almost the end of the administration.

Now, I'll come back to the mitigating factors there, but let me say I think that that obviously, I don't agree with that obviously, and there are multiple shortcomings in my view with that. First, at a very high level the announcement of withdrawal reinforces a pattern of a lot of uncertainty being created among our allies and friends in particular with regard to the reliability of the United States in meeting its obligations in supporting the institutions that we have spent 70 years building that

includes, you know, talk about NATO, talk about trade barriers, you go on and on and on with that.

Secondly, leadership in the climate discussion or activities, which of course, means an awful lot to a lot of our allies and friends was very hard won. And United States exercised that and most critically I would argue it was the joint announcement of President Obama and President Xi of China in November of 2014 that was the turning point. That's what made Paris happen and bring every country along. The old excuse China isn't doing anything was blown away in that joint announcement.

Now that leadership has been abdicated others including China have announced their intention of stepping forward. And I believe they will and I believe Europe, especially Germany will, India has said the same, but frankly without U.S. leadership in these complex activities there will certainly not be a complete filling of that role I'm afraid.

Third, the parallel activity I mentioned on innovation. So the administration put in a budget proposal to Congress that instead of taking that factor of two agreed to in Paris in the numerator they put it in the denominator to divide the innovation investments by a factor of two. That is connected in my view to the strong statements made by China and Europe and India in terms of leadership, because we're not going back we are going to a low carbon future.

It's going to be a little bit rocky for a few years with our administration's actions, but we're not going back. Consequently, there was little doubt that there will be a multi trillion dollar clean energy marketplace globally. That's a big market. If we want to, a) withdraw from leadership, and b) reduce our innovation investments believe me there are plenty ready to step in on that score and get market share. So --

MS. TIERNEY: Well, would you talk about China in that regard?

MR. MONIZ: Yes. Let me add just one last thing.

MS. TIERNEY: Yeah.

MR. MONIZ: And the -- this gets to -- not to the dissonance in two respects one is the dissonance that in

withdrawing from Paris many in the administration, Secretary Perry, Administrator Pruitt have said kind of look the solution anyway is innovation dissonance with the budget request cut by a factor of two.

Secondly, administrator Pruitt said immediately after the President's announcement the Supreme Court ruling holds on what is called the "endangerment finding" that is that carbon dioxide must be regulated under the Clean Air Act. Nothing was offered and again a dissonance, I would say fundamentally with the science, the science consensus. So I think on four counts this -- the administration's actions of the last month have been very, very -- "unhelpful," is a very mild way of saying it.

MS. TIERNEY: So I have so many questions, let me start with China then that multi trillion dollar marketplace is one in which you can imagine China going gangbusters to take advantage of that, and I am reminded of the theme of the new administration with regard to energy dominance. So how do those two things jive given that our cluck (phonetic) might get cleaned, if that's the right metaphor?

MR. MONIZ: Well, China is making enormous investments in R&D, in clean energy. Certainly, if the administration's proposal were to go through Congress, which I don't believe it will, but if it were to go through Congress within 5 years we would have gone from by far the leader in these innovation investments to being significantly behind both China and the EU. That's the first point.

Secondly, I want to emphasize China is not just investing in you know, renewable energy and nuclear energy, carbon capture and sequestration; they are doing that. But in addition, they are making breathtaking investments in the underlying enabling technologies for the future.

For example, United States has been pretty unquestionably, and DOE has been the lead in establishing our country as the leader in high performance computing. You look what China is doing right now it is incredible, including by the way recruiting back to China all those Chinese who got PhDs. in the United States and were happily working in our universities and companies. There's a lot of uncertainty now, a lot of reverse brain drain, if you like, going on there. So they are making impressive investments across the board.

Now, in the United States obviously we do have a very vibrant private sector involved in innovation, but the statements often made, I won't name names, that somehow the government does not play a role in this are completely false. And most in industry recognize that of the federal investments having a very critical role in getting things going.

A good example is -- now you mentioned -- and it -- because you mentioned energy dominance. First of all, let me say, I don't know what energy dominance exactly means if it isn't the picture we already have in the United States where I might say I'm not. It just happens to be a time period in the Obama administration when natural gas production went through the roof, when oil production went through the roof, when deployment of wind and solar and cost reduction of wind and solar, not -- I guess went to the basement in terms of the cost reduction et cetera. So this has been an incredible decade of energy.

MS. TIERNEY: It sounds like it's making America great.

MR. MONIZ: It preserved America's greatness actually. So that's really critical, but tying it back to the theme of federal investment if you take the -- and there are various views, but the fracking revolution that led to the enormous increase in oil and natural gas production in the United States, the reality is the Department of Energy in the late 70s, early 80s made the initial investments characterizing these reservoirs, supporting some of the technology development.

Then it was picked up in the 80s and early 90s by a public private partnership, Gas Research Institute in which cost sharing was done to demonstrate the technologies. Frankly, a legend in this is a guy named George Mitchell -- Todd, his son, I know is involved in the Ideas Festival today -- was a pioneer here.

But it was a public private partnership. With at the same time Congress putting forward in the 80s during the Reagan administration a time limited tax credit to get things kicked off, and then starting in the late 90s things began to just rocket. It was always the government working with industry hand-in-hand and with Congress to move things along. That's a story we can repeat over and over and over again, and I'm happy to do that right now if you'd like.

MS. TIERNEY: Go.

MR. MONIZ: Oh, okay. So for example the last years at DOE a new program was established called, ARPA-E, Advanced Research Projects Agency-Energy, modeled after the legendary ARPA of the Department of Defense. And I won't go -- I won't say into why? Let me just say the track record is -- its first award was made in 2010. It's a young program. 56 companies have been established from the awards made in that program in a mere 7 years. 1.8 billion dollars private follow-on capital invested in those projects.

I thought that's exactly what government was supposed to do, kind of get these things going and the private sector decides which ones to pursue. Secretary Perry early in March made a completely appropriate tweet praising ARPA-E as exactly the kind of program we need to support. That was 5 days before the OMB put out a budget recommending that it be eliminated. Again, this dissonance is just incredible.

But even more challenging in the discussions with those who feel government should kind of stay out of our way except for the objectives that we want -- we'll go into -- we can go into that as well, the loan program, the loan -- DOE has a large loan program that was authorized during the George W. Bush administration.

It has similarly kick started projects in the private sector that have been picked up, but instead of focusing on how risk is shared between the public and private sectors instead shopworn ideas are applied. Oh well it's okay if government works only on basic research, but they shouldn't be involved at all in any kind of deployment activity. Regrettably, I think there is not an evaluation going on what works what doesn't work what do we keep? It's a blunt instrument and it will really harm our innovation system.

MS. TIERNEY: Let me actually just follow up on that. You mentioned the proposed elimination of ARPA-E, but in addition the proposed budget would either eliminate or cut by half to two-thirds such programs as energy efficiency renewables programs at the office of electricity that make it so we've got a more vibrant grid so that all these smart things can go on.

MR. MONIZ: And resilient grid.

MS. TIERNEY: Absolutely. Additionally, the other energy programs would also be sliced. So what difference does it make?

MR. MONIZ: It was across the board.

MS. TIERNEY: Yes.

MR. MONIZ: Nuclear, fossil you name it all of them.

MS. TIERNEY: Office of Science.

MR. MONIZ: Office of Science, yes which is a backbone. In fact going back to the earlier, if I may put in a statement to the very beginning of this discussion when all of these different missions of DOE were mentioned and you ungraciously called it a holding company. I have to say that there is a thread.

The thread that runs through all those missions is science and applying science to complex problems. That's why we have a 17 national laboratory system. DOE is fundamentally a Department of Science and Technology Application. And so what was your question now? I forgot.

MS. TIERNEY: What difference is it going to make that all of this R&D from quite basic to commercial to deployment is if it were sustained in the House and Senate not only this year, but several years going forward?

MR. MONIZ: Right. And again, I say I'm fairly confident there'll be some nicks, but it won't be this wholesale slaughter of these energy programs when Congress acts. But nevertheless if we do ask what would happen?

As I said earlier there are so many activities here in the energy business -- it's very hard in the energy business with large scale -- the large scale, the large capital investments required, the large timescale, the strong regulatory constraints. There is a lot of risk involved in developing these technologies to scale up. Frankly, we've seen that -- we're seeing that play out even as we speak here those of you who have followed things like the Westinghouse bankruptcy and Toshiba's problems.

MS. TIERNEY: On the nuclear program.

MR. MONIZ: This is --

MS. TIERNEY: Yep.

MR. MONIZ: This is on four new nuclear power plants being built. The trouble is -- the scale is you know, you build two nuclear power plants in Georgia or South Carolina, which is happening and you're talking on the order of \$15 billion of capital. That's an -- those are enormous investments.

So there's all kinds of risk-sharing that has to go on for the system to work and in particular to accelerate the deployment of the clean technologies in ways that we need to if we are to meet not only Paris goals, but the goals that we will need after Paris, after the Paris timeframe going to mid-century. So I just -- it's just not going to work I think without a strong public-private partnership.

MS. TIERNEY: So there's been a lot of reports since the Trump administration announced it was going to pull out of Paris. And those announcements have pointed to the fact that so many states are moving forward with their own clean energy agenda.

So many cities and county governments have made commitments to dramatically reduce their greenhouse gas emissions and private businesses all around the country probably some of the ones that you work with have made commitments to zero carbon supply for the long term. So can we get there with that alone?

MR. MONIZ: So -- well, first of all, can we get there? We will get there. I think at some point we will see the federal government reengaging in this however many years that may take, but in the meantime what you've said Sue is absolutely the basis of optimism that we're not going to get deflected by too much at least and that's because you said, as you said mayors, governors, businesses, universities all kinds of civil society organizations have, shall we say risen up following the announcement to make clear that they are going to stay on track.

To give some numbers by the way by my count 22 states have already made those statements. I've forgotten how many -- many, many additional states, I've forgotten

the number where in particular the largest city in that state has made the similar commitment. 1,400 businesses have made that commitment.

I think the issue is going to be how can the governors -- in particular, the governors and the mayors -- pick up some of the international leadership vacuum? It's not so simple, but I think it's possible and some of you may have seen just as a kind of a note on that when Governor Jerry Brown of California, and obviously California is -- a) it's a huge economy and b) it's a leader in these areas when Jerry Brown was in China -- it's kind of unusual -- President Xi made a highly publicized photographed one-on-one meeting with Governor Brown showing this idea of looking for leadership.

And interestingly the Paris accord has a mechanism for non-governmental entities to attach to it. So putting that on steroids will be one of the activities going on over these next months.

But I do want to focus on the business commitment. To me that is the surest indicator that again we're going where we said we were going. Business people have long since concluded, certainly post Paris, but even before Paris that the handwriting is on the wall that we're going to a low carbon economy.

I remind people that a decade ago the oil companies, many of the oil companies were using typically a 40 dollar a ton of carbon dioxide shadow price in their capital allocation planning. That pretty much tells you what they were planning for.

Now, today utilities for example, but once again big capital decisions to make. They are not going to make those on the basis of a high carbon future. You're not going to see new coal plants being built. You might see some of the coal plants -- the existing coal plants run a little bit longer than they would have.

So there will be consequences, but frankly, and something Sue, you've been very strong on saying, a -- the big change going on with coal and nuclear in this country really is cheap natural gas; that's really the basis of what's going on.

It's a market phenomenon; not some climate policy, because indeed the climate policy for power plants,

the clean power plant was -- the administration said they're going to -- they're not going to follow, and this by the way I believe will come to pass; it will not be put into law. But it was only supposed to come into effect in 2022. To start blaming the loss of coal jobs, which have been occurring over the last 20 years on the clean power plant is ridiculous on the face of it.

MS. TIERNEY: It makes me sad whenever I see the coal miners from Appalachia standing up. The coal miners from Appalachia started losing their jobs when coal started moving to Wyoming and Colorado in this neighborhood decades and decades ago. So --

MR. MONIZ: In fact if I may just --

MS. TIERNEY: Yeah.

MR. MONIZ: -- this might be interesting to people that -- if you look at the number of coal miners per ton of coal produced in Appalachia, it's roughly eight times higher than in the West because it's a whole different surface mining, highly mechanized. And frankly, even that giant machine scraping coal in Wyoming is now becoming an automated vehicle. So even that one job, driving it, is going.

MS. TIERNEY: One of the things I think is interesting on a point that you made which is many of the electric companies around the country who have been -- have had their electricity mix dominated by coal for many years and especially by fossil fuel moreover have begun to make commitments about fully decarbonizing their electricity supply over a number of decades. And one of the things I think is interesting is that many of the studies of deeply decarbonizing the economy of the U.S. and the global community is to electrify many sources, many uses of electricity both in industry, in buildings that are now using natural gas and in transportation sector.

So it's actually pretty interesting that the electricity companies not only want to decarbonize, but they've got a growth opportunity. And how do we imagine that playing out between the, you know, the war of the titans from the oil and other fossil companies and some of the electric companies in terms of market share going forward?

MR. MONIZ: Yeah, it's -- we are in a very

dynamic period in this sector. First of all, let me say again in terms of factoids people might want to keep in their minds. At the beginning of the century, this century, coal was a bit more than half of our electricity supply, gas was maybe 17%-18% at that time.

Last year gas was 33%, coal 31%. So it's the first time in history that gas has surpassed coal and the trend lines will likely continue. And as was said earlier the main dynamic there is simply that natural gas is so abundant and so inexpensive. The -- and secondly by the way the -- that market dynamic of gas replacing coal is responsible for 65% of the reduced carbon emissions in the United States, it's been that -- market driven substitution which has accomplished that.

Now, you mention deep decarbonization. Maybe it's worth saying a word about what that is. So the Paris Agreement targets of the United States and of others were typically a reduction of CO2 emissions in the 25%-30% range in the timeframe of 2025 to 2030, you know, roughly speaking; the big bucket of commitments.

And that's great; it is -- it's an important step, but it's the first step, because without continuing on that reduction trajectory there is no chance of getting the kind of stabilization of temperatures that we aimed for. And so what it means is that by mid century let's say, especially the developed economies would have to be, maybe 80% reduced in carbon emissions, that's deep decarbonization.

How do we get there? First of all, electricity is the sector that is most decarbonizable. We have the most options there. And so if we're going to have deep decarbonization the electricity sector almost has to be close to totally zero carbon on a mid century timeframe. Now, when you look at other sectors however, let's say transportation, God gave us gasoline, an incomparable transportation fuel, very high energy density --

MS. TIERNEY: Really light.

MR. MONIZ: -- liquid. Any of us here can go and pump it ourselves. You know, it's really amazing; you have to overcome that. And so electrifying the transportation sector as much as possible has to be part of deep decarbonization, but in my view there's no chance of "decarbonizing" that sector for one -- and things like

airplanes would be a good example of it's hard to see a battery flying a Dreamliner, you know. Industry may be even more difficult.

There are some major plants, which are big CO2 emitters where you can imagine carbon capture, for example. But industry is very distributed, much smaller sources, how are you going to do that? Buildings. Well, we're probably going to have to switch a lot to electrification of things like heating, could be with heat pumps, could be direct heating, et cetera, which may be inefficient, but it doesn't matter on the emissions scale if electricity is decarbonized.

But you know, when I do my physicists' back-of-the-envelope calculation about getting to deep decarbonization, with the technologies we see today and their extrapolation for continued cost reduction, I got to tell you, I have a hard time getting beyond 50 percent.

So I think that's where the deep innovation agenda comes in. We need some big breakthroughs in areas that we don't currently see, you know, to get there. And that's why that innovation agenda today, because we're only talking 30 years away, and for this kind of innovation getting it all the way from basic science to lab to pilot to commercial to scaling that's a multidecadal process. So we don't have a lot of time to waste, but that's the agenda.

The good side of that, of course, is that's exactly the agenda that will capture an enormous share of that multi-trillion dollar market. That's where the jobs are, not in dreams of the past.

MS. TIERNEY: I want to ask you to talk a little bit about something people have called the Holy Grail. It might not be the one that you're thinking of when you and I talked before, but I'm thinking of storage. For decades and decades, as long as it's been since Thomas Edison started his little plant, electricity had to be produced exactly when it's used, because it's not storable for the most part.

But there are some changes underway, so that if you produced electricity from the sun during a sunny time of day, you could store it and use it later on. Or if

you're producing electricity from wind, when the wind dies down you could store it.

Now, that storage, there's a lot of work going on with storage that's quite precise. One second to another you could store electricity and then inject it back into the system. But between seasons of the year, when it's really sunny and windy versus not sunny and windy or peaks of the day that are off the charts, how do we think about storage and innovation and these decarbonization with technologies that right now aren't around the clock? And what's the outlook for storage?

MR. MONIZ: Well, okay, first of all, the issues of cost reduction for battery storage, you know, it's much maligned. But I've always said, it does follow a Moore's law. You know, Moore's law is that semiconductors double their power every 18 months. The only difference is that the time constant is a century rather than 18 months for batteries historically. But that's changed in the last years; dramatically.

So in reality battery costs, advanced -- now the advanced battery costs have come down 70 percent just in the last 7-8 years. And now you're seeing the -- so I want -- one part of this is, I've already counted that into my vision for the 50 percent --

MS. TIERNEY: Yes.

MR. MONIZ: -- that it's going to succeed. And if you look what's happening, it's really impressive. I would say right now utilities can make long-term contracts, 20-year contracts for getting photovoltaic energy supplied with substantial battery storage for probably around \$0.09 per kilowatt hour without subsidy. Of course, they're doing contracts now with subsidy, so it's maybe half that, but that is an impressive, you know, march to lower cost.

So I think, you know, that's why we're seeing a lot of storage coming in. In fact those of you from California in particular may remember a couple years ago there was the disaster at Aliso Canyon, this natural gas storage site, it's not functioning. But what happened was the two utilities down there put in almost a 100 megawatts of battery storage, and they just got through a horrible

hot spell without any major problems and that storage was a big part of it.

MS. TIERNEY: Because otherwise they were relying on natural gas to fuel power gas.

MR. MONIZ: Yeah, so the natural gas out of that field was how they managed to deal with peaks. So it's happening already. It's coming at us very, very fast. So certainly, this kind of storage on the timescales of like within a day, et cetera, I think we're not very far from having a major, major expansion of that capacity.

Now, if you get to seasonal storage that's a much more difficult issue. The obvious one, which is in place today but only geographically very selectively, is water storage; pumped water. So you -- you know, when you got the almost free juice, you pump water high, and then it's up there for whenever you need it. But that's not going to be a broadly available solution, if -- I'm not sure I have one.

Now, another one that is talked about in certain areas, which is much more difficult for me to imagine but maybe happens, people talk about heating up maybe a cubic kilometer of rock, you know, in the summer and have it available for the winter; so seasonal storage. So this is the message of deep innovation. We're going to try all kinds of crazy stuff, you know, that has some possibility of happening.

MS. TIERNEY: So what's your favorite?

MR. MONIZ: Well, you know my favorite, my favorite Holy Grail -- that to me was like a mini grail.

MS. TIERNEY: I know.

MR. MONIZ: The full Holy Grail kind of thing.

MS. TIERNEY: That's why he was the Secretary.

MR. MONIZ: No. But I think an example of a -- what would be a completely transformational technology, and it's done in the laboratory today, but nothing like the ability to scale it commercially and have it available at a reasonable cost. And that would be the conversion of

carbon dioxide. So let's say we capture carbon dioxide from plants or possibly out of the air, but let's say from plants. You combine it with water and with sunlight and you produce a hydrocarbon fuel that you just used to replace gasoline.

We have a -- DOE has a big program in that. It'll be decades if it works in a commercial sense, but there, for example, there's the answer to deep decarbonization. That alone could manage it; electricity, efficiency, and drop in hydrocarbon fuels, basically done, right. But you know, these are the kinds of long -- really long shots, and we got to -- we have to invest in, you know, five, six, ten of those long shots, and hope that a couple pay out.

MS. TIERNEY: All right. I have a whole list of questions, and I'm going to ask one more before turning to you. And this one occurred to me as I was listening to a conversation this morning about the combination of Big Data analytics; the technological revolution associated with institutions that set up platforms as opposed to providing a whole supply chain of things, and crowdsourcing.

So that reminds me of things that are going on in the electricity industry right now. Right now, you can -- if you're a geek and interested in figuring out your own electricity supply, you can put on solar panels. You can have an electric vehicle that you plug in. You could sign up for the next wall system, which is a battery. You could put in a Nest --

MR. MONIZ: Autonomous vehicle.

MS. TIERNEY: Autonomous vehicles. You could put in all sorts of gadgets to manage the electricity use and be pretty much autonomous, and you could do that in ways that supply to the grid or pull from the grid and essentially are crowdsourcing electricity supply. So how do you think of that? Is that a niche market going forward, or do we really see transformations in this industry as in so many others?

MR. MONIZ: I think this is very far from niche. In fact, let me, if I may, kind of take a little detour and then --

MS. TIERNEY: Yeah.

MR. MONIZ: -- come back. Or if I don't, remind me to come back. Okay. I will make a crazy sounding statement that maybe one of the biggest energy stories of the last couple weeks is Amazon buys Whole Foods. What the hell is the connection of that to energy, right? But what it says to me is it points out how the big IT companies -- you know, Google buys thermostats -- smart thermostats, right. Amazon -- Apple does autonomous vehicles, you know, we go on and on. And I think there's a real question to what extent.

It's the large IT integration which is underpinned by the technologies you said, including AI and Big Data analytics and cross-selling and everything else, is that going to be the future of every commodity. In the electricity sector, that development -- that's why the Amazon buys Whole Foods is so -- I think so salient to the discussion. In the electricity sector that, of course, at some point runs head-on into the regulatory structure, because in the -- of course, in the electricity sector, historically we had the most stodgy of all, you know, cost-of-service, regulatory structure vertically integrated --

MS. TIERNEY: Monopolies.

MR. MONIZ: Utilities, monopolies, et cetera, et cetera. Now of course that's been -- starting in the 90s especially-- that's been changed with many parts of the country, and in particular with so-called deregulation. But deregulation is not what people in other industries would call deregulation. And so for example, a major part of the action I think is going to be that whole Internet of Things, which in the home environment means all those gadgets with you know, with addresses --

MS. TIERNEY: That you can talk to.

MR. MONIZ: That you can talk to, and they can -- well, actually they're probably not going to be terribly interested in that. They want to talk to each other and talk to the outside world, et cetera.

MS. TIERNEY: And tell them all about you.

MR. MONIZ: Exactly. And it's interesting, right now regulation could be viewed by the utilities as a safe harbor for their work in front of the meter; protect us, don't let those come -- Amazon et cetera, et cetera over what we do. But that safe harbor would keep you from behind the meter, which was where all that Internet of Things is going to happen. So I think that the business model in utilities and the regulatory model together have got to find some evolution in a world of Big Data.

And one other thing for the utilities, of course, is you know, business models tend to be stressed when the market isn't growing. And the electricity market is not growing. In some parts of the country, it's gone down. And of course, success in our efficiency and demand side management will only exacerbate that.

So what is the business model? I think it's got to be -- if they're going to survive, it's got to be somehow to be in that competition with these Big Data companies in terms of who owns that space. A few months ago, I don't think he's here, Tom Fanning, a good friend. He's the CEO of the Southern Company.

MS. TIERNEY: They actually were a sponsor.

MR. MONIZ: They're a sponsor. No, they are a sponsor. I don't think Tom is here, but --

MS. TIERNEY: Yeah.

MR. MONIZ: They are a sponsor, correct. They have a little house out there with microgrids and stuff. And actually Southern Company is in a part of the country that is the most regulated. They have been very adventurous in technology and in R&D and all kinds of things, et cetera. But I was at a meeting with Tom in Atlanta a few months ago and I said, my summary of this last discussion was, "I'm going to be very curious in 10 years to see whether Google works for Tom Fanning or Tom Fanning works for Google." He was less than amused than the audience.

(Laughter)

MS. TIERNEY: The concept of moving from a vertically integrated monopoly to a platform provider as

we've seen in so many other industries is kind of the topic.

MR. MONIZ: Yeah. And providing new services.

MS. TIERNEY: That's right.

MR. MONIZ: And providing cross-linked services. That's where we're going.

MS. TIERNEY: And making sure that the grid remains resilient, able, and everything else.

MR. MONIZ: Right. And by the way, just as a last aside on that and then I was going to couple that as well to the whole vision of a whole different city built around autonomous transportation. It's going to be an interesting couple of decades.

MS. TIERNEY: It's an exciting time. Who has a question? Sir, would you introduce yourself, too? And here comes a microphone to your left.

MR. WAYNE: Thank you. Bruce Wayne from Washington D.C. My question is automobiles. In the future, what is the future of gasoline use in automobiles? What percentage of automobiles will use gasoline do you think let's say 10-20 years from now?

MR. MONIZ: Well, I'm not --

MR. WAYNE: Well, what role would that play in, you know, cutting carbon percentage wise?

MR. MONIZ: Well, again, it's not -- I'm not going to give a percentage, but let me say that, first of all, in the United States and globally, as you know, urbanization is the trend. And by 2050, I think the UN projection remains that the world's population of 9.5 billion or whatever will be 70 percent in urban environments.

I believe, those urban environments will be transformed in many ways by electric vehicles and autonomous electric vehicles with very, very different ownership models. Look, we're seeing it already today,

right, our kids -- or in my case maybe in a few years my grandkids --

MS. TIERNEY: My kids too.

MR. MONIZ: -- you know, they don't want to own. They want these different ownership models and Uber versus taxis and you name it. So I think there's going to be an enormous market for an enormous deployment of light duty vehicles in those urban environments. I find it harder to see that happening to that scale in the bigger distance, heavier vehicles.

Although even there the extent to which something like trucking devolves much more into point-to-point travel, which is now maybe 20 percent I think of the heavy trucking market, that actually could go in the direction of these alternative approaches. If it's not electricity in terms of storage, it could be a fuel cell technology, for example, where the refueling parts aren't so difficult if you have fleets and it's point-to-point.

So I think there can be a big transformation, but really heavy vehicles, certainly again I mentioned airplanes, some marine transportation. It's going to be hard to, I think, to displace those liquid fuels. Maybe my Holy Grail will replace them in a clean way, but -- and by the way, and of course it all hinges in terms of emissions on getting that zero carbon electricity sector.

MS. TIERNEY: Yes. Okay, I see a question here and then -- okay, I want some diversity. There's one, a non-wonderful diverse person, next one here.

MR. HAYFLICK: Yeah, I guess, I'm a non-diverse person.

MS. TIERNEY: You're -- you are a diverse person.

MR. HAYFLICK: Hi. My name is Jack Hayflick (phonetic). I'm from New York City. I'm intrigued by the battery --

MR. MONIZ: See, that does it, New York, there.

MR. HAYFLICK: Yeah.

MS. TIERNEY: Exactly. Washington, New York.

MR. MONIZ: Right.

MR. HAYFLICK: You got it. I'm intrigued by the storage concept, storage of electricity, use of batteries. My understanding is that most of the world's supply of the rare earths that are required for batteries are in areas of the world where it's politically difficult to get some of them out. Could you comment on that please?

MR. MONIZ: Yeah. So there was a -- in particular, a flurry of activity, I forget now, maybe it was close to a decade ago when China decided -- China was the major exporter of rare earths and they decided to stop exporting.

They were actually ticked off with Japan, as I recall at the time. That has ended and other sources have been developed, which has got -- which has brought the costs way down. But I think you know -- I think the thing you -- what you raise, I think, is a very important point, and it's not only rare earths. We just saw an article on helium recently.

To what extent, for critical materials, are we going to rely on a global market versus having at least some kind of strategic reserve? We have that for oil, although in my view very unwisely, this administration has proposed to, in the end, reduce the petroleum reserve by almost a third. And we could go into that discussion as well, but I think the whole issue of strategic reserves of critical materials is one that's not been well thought through.

On rare earths, the Department of Energy did establish about 7-8 years ago a center at Iowa State University that looks at the issue of recycle of those rare earths, so make as much use of them as possible, and very importantly to look for substitutions of more common elements for critical applications. So that's the kind of R&D and innovation that's going on which can obviate some of the risks that you talk about.

MS. MITCHELL: Thank you, Mr. Secretary. Andrea Mitchell from Washington D.C. Let me ask you about another part of your tenure. Just 2 years ago, you were

instrumental during marathon nuclear negotiations in Vienna.

MR. MONIZ: With you.

MS. MITCHELL: Well, I was an observer. You were the key player. If the administration decides to dismantle that aspect of the legacy as well, what are the implications? Can the deal or the central components of the regulatory structure, the IEA monitoring survive if the United States cancels its participation in a multilateral agreement such as this? Or does it collapse of its own weight because of the likely Iranian geopolitical implications of that? And if you want to talk about --

MS. TIERNEY: And if you back up a minute --

MS. MITCHELL: As -- decades ago I was an energy correspondent. If you want to talk about the Strategic Petroleum Reserve, I invite you to discuss the implications over the decades of it being used to affect prices, rather than supply.

MS. TIERNEY: It wouldn't be the first thing that was an strategic energy activity when you think about natural gas and the Ukraine.

MR. MONIZ: Correct.

MS. TIERNEY: Lots of things.

MR. MONIZ: Right. Okay, so shall I try --

MS. TIERNEY: Absolutely.

MR. MONIZ: Do the Iran -- okay, so the Iran question, a little bit different from this subject, but let me just say that if -- I think if the United States were to withdraw, if you like, from that agreement, we would have the worst of all worlds. First of all, the idea that economic sanctions would be effectively restored is very hard to believe since the success of those sanctions, which did in my view play the major role in bringing Iran to the table, could not have worked without international cooperation.

And that cooperation was well beyond the negotiating countries that also included Japan and India, et cetera, all withholding payments from Iran for oil deliveries and the like. So that -- so we will not have the economic leverage that we had before. In terms of what would happen in Iran, it's a little bit of speculation obviously.

But I have been, for one thing, encouraged by some Iranian steps with the Europeans in terms of joining forces in developing norms for -- like nuclear safety. So this -- that is they're acting as though for the longer term they want to be involved in the nuclear power business and have safety come in, et cetera, et cetera.

However, what -- my guess, Andrea, is that what would happen is that Iran would, in my guess, largely continue the nuclear restrictions placed on them to keep European, Russian, and Chinese cooperation. But I suspect they would back off from the unique verification measures that the agreement has in place because then the argument will be -- is, "Look, we're good citizens. The United States is not.

And why should we do things now that nobody else in the world does? Why should we have 25 years of uranium supply chain surveillance, you know, et cetera." Those things. And of course, it was exactly the extraordinary verification measures, which made the agreement possible, because nobody trusted Iran and there's still a lot of mistrust.

So anyway -- so I think that's what I would guess would happen. We're much better off certainly. Following this through, clearly, we have a lot of other problems with Iran that we have to resolve separately and with great pressure; Hezbollah, Syria, Yemen, missiles, human rights, all of that.

We got a lot of problems, but I also think -- and this is something -- okay, I'll say here that I'm planning to start also a project. Why don't we start looking -- I mean, those of us in the -- now in civil society start looking at Iran the day after. What do we want to see in 15 years?

Let's assume the agreement. This agreement does run its course for the nuclear restrictions. Well, what do we want in 15 years? What do we want to continue to assure the international community that Iran is following a peaceful program in ways that makes sense for the international proliferation -- non-proliferation regime?

MS. TIERNEY: Another reason why I'm glad that Ernie Moniz was Secretary. Question over here.

MR. MONIZ: You want to do the SPRO. She also asked SPRO, but we'll not go -- we're going to SPRO, okay. No, she asked SPRO also.

MS. TIERNEY: Oh, I'm sorry. I didn't hear it.

MR. MONIZ: But no, but it's all right.

MS. TIERNEY: Go ahead and talk about SPRO, the Strategic Petroleum Reserve.

MR. MONIZ: Well, it's -- okay. I'm going to be just -- I'll be very brief. Yeah, SPRO is the Petroleum Reserve. It is -- there's our -- there's nearly 700 million barrels of oil in underground caverns in Louisiana and Texas. This was established in the 1970s in response to the oil embargo, especially the first oil embargo in '73. We do this in collaboration with other -- the other OECD countries.

MS. TIERNEY: Formerly consumer countries. We're now a producer.

MR. MONIZ: That's right. Well, we're still a consumer. We're still a big time net consumer -- net importer. But everybody, including in Congress these days and the administration, they focus on a criterion for the petroleum reserve size that may have made sense in the 1970s and makes no sense today.

Specifically, it says we should have 90 days of imports in the petroleum reserve. And today because of our increased production, we have about 135 days in that petroleum reserve.

However, many of our institutions, including the petroleum reserve, still live in the 1970s and the global

oil market today looks nothing like the 1970s, nothing at all. It's hard to remember. There were no futures contracts. There was nothing.

We didn't have the diversity of suppliers. Today -- and this may get dangerously close to your admonition about prices, but the reality is even with our increased production, we are and will always be linked to the global oil price.

So a major oil disruption in the world, and you don't have to think too hard to see how some things going on in the Middle East could lead to substantial disruptions, could cause an enormous price spike that historically has always led to like 1 percent hits on GDP; big time hits on GDP. I think we need to have a robust -- it's an amortized cost. We need to have a robust SPRO, I think, to manage those kinds of risks and with new authorities, but that's a longer story.

But certainly I might say that in the last few years the petroleum reserve has been used now four times: once for energy security, once for deficit reduction, once to build roads, and once to cure cancer, the Cures Act.

MS. TIERNEY: The last one is a surprise.

MR. MONIZ: The Cures Act also sells oil for cancer research. It's become a piggy bank without any concept of a modern view of energy security.

MS. TIERNEY: All right. We have time for one more question, and it is the blue vest over there, because I promised.

MR. OVERTON: Thank you. Bill Overton (phonetic) of San Francisco. As you have talked about -- what we've seen happen with natural gas supply in this country through technology and capital markets working has taken an energy source that was maybe 10 years to somewhere between 50 to a 100 years. So we have this incredible abundance of a low-carbon resource, a relatively low carbon.

How can we transform this into, if you think decarbonization through electrification is the way to go, how do we do that? And it's probably the role of public

sector. Is it not? How do we upgrade our grids so that we can take nat gas from 33 percent to 70 percent?

MR. MONIZ: Well, first of all, 33 percent to 70 percent would get you into carbon trouble. In principle getting you to 60 percent could lower carbon. But gas -- look gas is going to keep growing for a while. The gas revolution you said it, but let me say a couple -- a little bit more about it. The gas revolution has made this change in electricity production that we've already discussed, but it's made a lot of other very, very big changes also. It has been an enormous stimulus to manufacturing in the United States.

And I don't mean just petrochemicals, because the reality is that a lot of industries need heat, and they're getting their heat a lot more cheaply today. There's been a \$185 billion invested in petrochemical plants, largely in the Gulf but also in the Midwestern and Northeast. So it's been a complete game-changer, incredible.

And that will continue. However, if I go to my deep decarbonization scenario, gas substituting for coal will lower carbon, but even today we are seeing an issue. Suppose 20,000 megawatts more of nuclear power shuts down in the next 3 years, and that is not an idle threat. I mean, this is --

MS. TIERNEY: Could happen.

MR. MONIZ: There's about 20,000 more megawatts that are at risk, I would say. You'd agree with that --

MS. TIERNEY: Out of a 100,000.

MR. MONIZ: Out of roughly a 100,000. If those were replaced even by high-efficiency natural gas, we would lose about a third of all the progress we made in CO2 reductions. So that's just a sign that when we go to deep decarbonization, either we start capturing the CO2 from natural gas, or it's too carbon intensive.

So that's a probably -- if I had to guess, a 20-year inflection point from now. But that's the kind of thing we need to think about in looking at -- looking at the mid-century outlook.

MS. TIERNEY: Well, thank you, Secretary Moniz
for --

MR. MONIZ: Thank you, Sue.

MS. TIERNEY: -- giving us this tour.

(Applause)

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