INTERVIEWER: This is the MIT 150th anniversary interview with professor Ernest Moniz. And let's start with your background. Where were you born? Where did you grow up?

MONIZ: Well, my background is one of a local boy come home. I was born and raised in Fall River, Massachusetts which is about an hour drive south of Boston. I did then wander to California for my graduate school, to France for a postdoc, made an investment there in getting married, and then came back to the states and to MIT, which was, of course, a great attraction, certainly in my area, in physics. I think frankly, the leading department in the States, in the world, and it's been a great career here for 37 years.

INTERVIEWER: Tell me a little about your family of origin.

MONIZ: Well, my grandparents were Portuguese immigrants, part of the Labor Movement that came to the States in the early 20th century. And I would say in Fall River, in those days at least, I was the beneficiary of a good, strong public educational system, a family that understood education as a way of having a fulfilling and rewarding life. And I think that's the fundamental trajectory.

INTERVIEWER: Were there any particular events or influences when you were growing up that you think influenced your career choices?

MONIZ: Career choices were definitely influenced by various factors, and quite honestly, MIT had a major role in them. The first was that, following Sputnik, there was the very well-known and famous development of a new high school curriculum in physics, the so-called PSSC, Physical Sciences Study Committee. Again, that was established post-Sputnik to change physics education from one in which one looked at steam shovels in books to one that was based instead upon physics experiments, problem solving.

So I took that course, literally, in its very first year of being offered. I mentioned earlier that I think we had a strong public education system. And what this meant in this case, frankly, was a high school teacher in physics who found the material, frankly, a little bit beyond his capability, but understood that he had to teach it. And so in a certain sense, we learned it together. And it was really a very important, and for me, certainly, a defining experience.

The second element was, again, along the themes mentioned earlier in terms of family and support for education is that my father, who himself did not have a very extensive formal education, shall we say, always said MIT and engineering were the two things that I should remember in terms of a trajectory. So even though I did not go to MIT as a student, the idea of MIT, the idea of a dedication to science and engineering, was something that was actually instilled quite early.

INTERVIEWER: Were you always good in science? Were you always interested in science?

MONIZ: Yes.

INTERVIEWER: So how did you come to decide on BC for undergraduate study?

MONIZ: It's not entirely clear. When I applied, it was certainly not my first choice, to be perfectly honest. I got into all the schools I applied to. But somehow I found the combination of Boston, perhaps a little bit lower pressure, as a very, very attractive-- it was a good fit. And it proved to be that. In fact, I was very fortunate at that time-- well actually, still today I believe-- Boston College had a special program in which a small number of seniors were called scholars of the college and could construct their own curriculum, often do research. In some sense, more of a British tutor system.

I did that, had a terrific faculty mentor-- Joe Chen was his name-- did material science in fact, at Lincoln Laboratory, another MIT connection. And it was quite remarkable that I could build, literally build my old laboratory, with a spin resonance device constructed on a shoestring, which was very educational. I think we spent $10,000 to get a device that was within an order of magnitude, certainly, in performance of a multi-hundreds of thousands of dollars piece of equipment. Did some very, very nice work on the synthetic ruby. And it was a terrific educational experience.

INTERVIEWER: Was there any question ever that you were going to do physics?

MONIZ: Not-- once I did PSSC physics in my senior year, it was pretty clear. I think, in that sense, I had a one-rail mind. Much narrower than one-track. And that was it.

INTERVIEWER: Do you have a sense of what it is about physics that sort of captivated you?

MONIZ: I think fundamentally the approach to structuring problems. I mean, physicists, I think, have a skill-- if they are successful-- I think, at simplifying problems, at structuring them, getting to the essence of the issue, and then, at least, in more cases than not, being able to derive effective solutions. I should say that I've had a somewhat checkered career in the sense that my PhD is in theoretical physics. Perhaps that's why I'm describing this issue of deriving solutions. Although I've had a substantial role in the experimental world, starting in my graduate career when I did some experimental work at the Stanford Linear Accelerator in its very earliest days. And then here at MIT for 100 months, I was the director of the Bates Linear Accelerator, which is a Department of Energy user facility that MIT operates about 25 miles from campus.

So it's been very interesting from that point of view, spanning a variety of worlds within physics and as we will undoubtedly discuss, outside of physics as well.

INTERVIEWER: So how did you decide on what to do for graduate study? Where to go?

MONIZ: As usual, kind of serendipity. I was fully intending to go to Princeton-- had a wonderful visit there, they were wonderful. Princeton was at that time considered the lead university in theoretical physics. So it all fit. But on kind of a March 14, spur of the moment-- March 15 being the response date. Or maybe it was April, I forget. But this is a first public confession. That *Newsweek*, I guess, had a slow week. And they pulled out a file story with a young fellow with a girlfriend sitting on a motorcycle driving into the sunset, and I went to California and Stanford. And that's the truth. And I will at least vouch for getting a motorcycle. I'll leave the rest aside.

INTERVIEWER: I totally told my son, you should think about the weather when deciding.

MONIZ: Yes, it was very good choice in the end. Stanford was very exciting at that time, a very small class, 25 students per year. And also it was the-- literally, it was the first year-- actually, it was minus one the year when I went. Of bringing into operation the SLAC electron linac, which at that time was much, much higher energy than anything which existed in the world. So it was a very exciting time, starting up a brand new program with a frontier machine. I took part in that. But frankly, what happened, is then I decided that I just didn't fit with the cultural aspects of high energy physics.

I'm not denigrating them in the sense that, for some, it's a wonderful environment to work in. But I just felt the groups were too large, which means at that time, there were perhaps 25 PhD's involved in a major experiment. Today that number is closer to 1,000 and there are very interesting issues about intergenerational experiments being carried out. But whatever the case, for me, I decided that I preferred more of a one on one working relationship. And so I went back to the main campus and into theoretical physics. So it was a very, very different trajectory, but I think the idea that one can be flexible and adjust to circumstances whether they are professional or peripheral, I think, is a good thing.

INTERVIEWER: Well, it shows that you knew yourself well and how you wanted to work.

MONIZ: Or possibly didn't.

INTERVIEWER: Either way.

MONIZ: There are two possibilities.

INTERVIEWER: So after your doctorate degree, where did you go next?

MONIZ: Well then I had a National Science Foundation post-doctoral fellowship, which I chose-- since I had my own funding, basically, I chose to divide that between Paris, a laboratory called Saclay, and the University of Pennsylvania, where I was attracted by a specific faculty member, Henry Primakoff, who I had met at summer school a year earlier in Sardinia. So I basically split my time between Paris and Philadelphia with a summer at Los Alamos.

And it was very interesting. A little bit disjointed, but it gave me a good feeling for, first of all, different physics problems and second of all, very different environments for doing physics. As I mentioned earlier, the Paris part of it also add the collateral benefit of meeting my wife. And we were married, in fact, in Paris near Saint-Sulpice, which you may recognize from recent literature. In any case, so I was a postdoc for two years and then came straight to MIT on the faculty.

INTERVIEWER: So how did you wind up at MIT? Did they approach you?

MONIZ: Yes. So I was approached-- basically, it came from well, of course, publications, but my stay in Los Alamos. It was once again kind of serendipitous, a faculty member at MIT, Arthur Kermin, spent summers as well in the DOE laboratories. And it just happened that he had a graduate student who was working on a thesis that was very close to part of the thesis that I had done at Stanford. And he asked for us to get together on a blackboard and talk about this problem. And I think another great thing about MIT, and about Arthur in particular, is that my stating that they had it all wrong was not viewed as a bad thing to say. Instead I got a call that why didn't I come interview for a faculty job. So it's really, it's all kind of serendipitous.

But certainly, when the offer was extended, there was zero probability that I would not take it. It was a very exciting time. It was again, I would say, the leading group anywhere in the general area in which I was working. And it was also the beginning, really, of a new experimental program that was going on at MIT at this Bates Laboratory 10 years before I became its director. And elsewhere as well, including at Los Alamos. So I was in kind of the orbit of new experimental facilities although I was personally doing theoretical physics and analysis. So it was a very, very exciting time and again, I'm certainly very pleased that it all worked out the way it did.

INTERVIEWER: Your father must have been so happy.

MONIZ: Yes, he certainly was.

INTERVIEWER: When you first got to MIT, can you talk a little bit about what your first impressions were? You had studied at a couple of different places. What stood out about MIT to you?

MONIZ: I think the first impression has been a continuing impression. Number one, extraordinarily talented students, and different students. And I say that in a very, very positive way. I think MIT students-- and especially undergraduates-- frankly, I think, often, shall we say, a little quirky, a great positive feature. And I think very, very creative. I frankly think that the MIT student body as a whole I find creative at a different level from what I have personally observed elsewhere. Maybe that's a little bit of rooting for the home team, but I firmly believe that. And that I think is the number one overarching quality and impression that I had then and that I retain now. Now of course, faculty colleagues are also critical. And they have been absolutely wonderful.

And I see that perhaps in a broader way than many, at least, do. Because my own career has taken so many changed directions, not only starting as a theoretical physicist and then being director of a large experimental laboratory, also administration-- I was department head in physics. But then following a government career, if you like, coming back. Totally changing direction in the energy space, which brings me into much more interaction with engineers, Sloan management, humanities, architecture and planning. I think I've had a career in which, here at MIT now, I have directly interacted with faculty from all five schools in a substantial way in terms of research as opposed to, let's say, administration. And so I think I have a really great appreciation of not only the quality of the faculty, but the way in which we are able here, I think, to work across organizational boundaries. That I think is very, very unusual at other universities. So that's, I think, been very important.

And then-- so students, faculty-- and a third impression that I consider to be a permanent one. And again, I say this in a positive way. Is that the-- I mean, I'm a physicist by training, but I would say MIT basically is fundamentally an engineering school in terms of the culture and the way things work. And I think that permeates the entire Institute. I associate that with a dedication here of just getting the problem solved. That sometimes is reflected in a lack of interest in some of the faculty governance issues, for example, which I interpret not as a lack of interest so much, actually-- it appears that way, but I think what it really is, is we have people who are supposed to solve those problems. I'm going to solve my problems. Unless, of course, there is a need to intervene in other issues. So I think it's again, it's students, it's faculty, and it is this idea that we don't have time to do anything other than solve problems. So I think it's really quite a special place.

INTERVIEWER: So what is it like being a theoretical physicist in an environment where there's such a push to solve the problem and build a solution?

MONIZ: Well, theoretical physicists are also solving problems and building solutions, so that's, I don't think, any different. In my own case, now, I think my colleagues would support the idea that I'm sort of no longer a theoretical physicist. Certainly that is not what I do now in research. What I do now, principally, is work with colleagues from different departments and schools in terms of looking at the very difficult energy challenges, particularly the intersection of energy technology and energy policy issues, which is a different set of problems to solve. But it's all about solving problems. It's just that the problems change.

INTERVIEWER: So can you sort of walk me through your research over the year and perhaps how things led to other things?

MONIZ: Well, in terms research trajectory, again when I came here, there was a new experimental domain opening up that involved essentially the interaction of high energy particles with atomic nuclei, which, in turn, was related to understanding the short-range structure of atomic nuclei, of understanding at a microscopic level the forces between neutrons and protons, nucleons. And that is the area in which I worked, initially. I think helping, for example, to define the theoretical construct by which one studied such reactions and this kind of physics.

There came a second period in which I looked at the next level, if you like, in terms of the quark structure of nucleons and how that, in turn, led to forces between strongly interacting particles and the structure of nuclei. At that same time, I was-- again, I was director of the Bates Laboratory-- and while I did not do the experiments directly, I think working with my colleagues, we shaped a brand new program at the laboratory that brought it into a kind of second phase of the experimental program. And that, in some sense, defined about a 20-year program at the laboratory, going into the last decade, in fact.

Then, however, I took a big detour. And served in the government, in the Clinton administration, for about five and a half years in two stints. And then that led, when I came back, to a decision to totally change direction and go into the energy technology and policy arena, which of course then, at least, positioned me for what then became the institutional priority for looking at energy and environmental challenges as manifested now in the MIT Energy Initiative that I am trying to direct.

INTERVIEWER: So I would like to spend some time talking about energy. And I have some general questions. Can you summarize how you see the energy challenges that we face?

MONIZ: Well in the end, there are multiple challenges in energy. One is simply meeting the demand, particularly in the developing world. We tend to forget that there's still over a billion people on the planet with essentially no energy services, which obviously is very, very limiting in terms of not only economic performance but education and all kinds of issues.

There's a second issue around the security of energy supply, oil being of course the most obvious example. However the third major challenge in the sometimes called perfect storm of energy challenges, is the one that frankly drives me most directly. And I think many others as well. And that is the question of mitigating the risks of climate change. And this is the most challenging of those challenges. Because the way one mitigates climate change risk in the energy sector is by limiting the use of carbon. The trouble is that today, 85 percent of our energy is carbon-based, it's fossil fuels. So what we're talking about is a profound transformation of the energy system. Now, historically, for a long time, we have been on a path of decarbonizing energy, coal to oil to natural gas, now to at least, perhaps the beginnings of a major penetration of nuclear power and renewables. So there is this kind of march towards decarbonization.

The problem in terms of the climate change challenge is that we don't have time to wait for the normal pace of change because these changes that I have characterized are typically on a 50-year time scale. Well, we don't have 50 years if we are to change the system to a really low carbon system. So the next one to two decades are the critical period for this kind of change. This puts a premium on innovation: technology innovation, policy innovation, business model innovation, all working together to accelerate this transformation to low carbon. And I think that is-- when all is said and done-- that is easily the principal theme for how we here at MIT have kind of organized our large- scale energy initiative.

INTERVIEWER: How do you get that change to filter down and cross government barriers? And reach people who don't want to give up anything?

MONIZ: The implementation of this change is indeed challenging. I personally believe that the mantra that we've had for quite some time that policy-- low carbon policy, climate change policy-- would in some sense pull technology innovation, is actually wrong. I mean, it's not a silly position. But I would argue that by observation, getting a biting carbon policy in place has proved, of course to be very, very difficult.

For all kinds of reasons, domestic reasons such as the willingness of the public to pay higher energy prices, for example, has not been manifest. In a country like United States where we are very, very heterogeneous by region, let's say, in terms of our energy sources and energy uses. We have interregional distributional challenges, shall we say. And then globally, we have the challenges of countries at very, different stages of development have very different ideas about priorities going forward. So when all is said and done, I do believe that we need policy innovation and we need carbon policies. However, I would turn the earlier proposition on its head and say that I think we need, probably, technology innovation that lowers the cost of low carbon approaches to lead policy. Because policy will be a lot easier to implement when it doesn't cost much.

And I think that's true in industrialized countries, but it is especially true in the emerging economies-- China, India, and certainly the less developed countries, they just don't think they can afford-- right or wrong, they don't think that they can afford the higher costs associated with many of today's low carbon approaches. And so I think the-- I think technology innovation that lowers cost of low-carbon alternatives, is actually the key. And other things will follow from that. In particular, low carbon policies.

INTERVIEWER: So is there-- do you have in your mind a scenario for how this might unfold in the next 20 years?

MONIZ: Well I think the key is first in this decade. And in this decade, two things need to happen if we are to achieve the kinds of CO_2 reductions, accelerated CO_2 reductions, that we are talking about. First in this decade-- you know, somewhat arbitrarily, let's take it in 10- year chunks. In this decade, we need to take advantage of the low cost opportunities that do exist for going to lower carbon. And certainly for the United States at appreciable scale, those are two. First is reduction of demand, higher efficiency in buildings, in the transportation sector. These are cost effective actions that we can take.

Buildings, for example, use about 40 percent of all energy use. Seventy percent of electricity use. When we are-- when we insulate a building, when we use higher efficiency appliances, we are reducing coal use, for example, reducing carbon emissions. Because in our country, half of our electricity is from coal, and many of these actions are certainly cost effective over time. They may require some up front capital investment, a slightly more expensive refrigerator or something, but with a relatively short payback period. And certainly some of the house energy efficiency improvements are very inexpensive. However, we have a very fragmented system. We don't have the kind of policy coherence that we need to really implement a lot of these steps. But nevertheless-- so that's one key step for this decade is we have to move on the so-called low-hanging fruit of energy efficiency improvements and energy demand reduction.

The second major action that we can take and certainly in the United States, in this decade, would be to substitute natural gas, which is plentiful in the United States, for the oldest, least efficient coal plants. That's something it turns out we can do today, in principle, with no capital requirements at all. And we could probably achieve the order of a 15 percent carbon emission reduction from our power sector literally with no capital investment. So those are two things that in this decade we can do that really take appreciable bites out of the carbon emissions that we have today.

However, as we go to the next decade, we need to start implementing at a much larger- scale. Let me call it the zero carbon options. Like more nuclear power, and like more wind, and like more solar, and perhaps as well engineered geothermal systems and other kinds of renewables. Well for that to happen at a large- scale, let's say in the next decade, we have to use this decade to get those costs down. Because right now, certainly offshore wind, solar-- the need to combine those with energy storage to remove the intermitency. These are areas where we need to advance technology. We need new solutions that cost less. And so this decade is critical both to take advantage of the couple of areas where we can reduce carbon now and to prepare the technology options for the marketplace for the next decade. If we don't get those two things done in this decade, it's going to be very hard to meet anything like the kinds of carbon reduction goals that are being talked about as prudent in minimizing climate change risks.

INTERVIEWER: Do you feel like the technology is close enough so that it can meet that 20-year horizon you're talking about?

MONIZ: I think I'm very encouraged. I think in the end, the technology will not be the limiting factor. Although that is assuming that we, frankly, ramp up the level of investment that we are making in the entire innovation chain. From the basic research that underpins new technologies to development of technologies that, for example, entail more efficient use of what we do today to the more breakthrough and transformational technologies like, let's say, advanced solar. Where we know the resource is enormous, but we have to pull together lower cost technologies for the system and, as I said, also address in that case the intermittency issues. Through energy storage and through a certain degree of balancing the variable sources like solar with, let's say, natural gas, which is a way of ramping up and down to meet load.

So I think we can do this. Certainly at MIT, our flagship program that has emerged is clearly solar energy, where we have-- I mean, the order of 50 faculty-- engaged in all kinds of solar research. From improving, let's say, traditional silicon-based based photovoltaics, higher efficiency, better manufacturing processes, solar concentrators-- that bring more light to bear on the relatively expensive materials. We have novel materials, quantum dot materials, polymer materials. We have biologically self-organized systems, we have water-splitting, we have novel ideas about concentrating solar thermal. So we have a multiplicity of approaches.

We've had several spinout companies in solar just in the last couple of years coming from MIT laboratories. Obviously, there's a lot of work elsewhere as well. But here at MIT, we see the incredible amount of activity and of novel ideas. Just recently, one of our sponsors is Eni, the Italian oil company. And their flagship program here is advanced solar. And their CEO came to dedicate a facility here and was stunned to see the first writing of a photovoltaic on a piece of paper done by one of our faculty, Karen Gleason, in fact.

So I think there's tremendous number of novel ideas and, just this example of writing on paper, is just one example of the idea that new kinds of materials and substrates that might materially lower costs for the entire system is critical. So that's all a long way of giving an example and saying that I think I'm very optimistic on the technology side. But we do need to ramp up the support. Recently, there was a very well-known group of CEO's in the United States-- Bill Gates, Jeff Immelt, Ursula Burns, you can go through a long list-- John Doerr from the investment world, forming the American Energy Innovation Council.

They went to President Obama recently with the product of their work. Most of them are not themselves directly in the energy sector. But they looked at this as an overarching challenge and one in which they felt we needed to have at least about a factor of five increase in the federal investment in energy technology and innovation. And that is, they are a very interesting group to make that statement, but I must say, it follows in a set of statements with more or less the same message for the last 10, 12 years. And we just haven't been able to ramp up the investment older than the one-time infusion from the so-called stimulus package. But now the danger is, of course, with our very tight national budgets, that we may just flip right back to the level that we had before. And so that certainly is a concern.

INTERVIEWER: So for somebody like me who has a fair amount of faith in technology being able to develop what's needed, but I also have very little faith in the policy changes that are needed ever happening, how do you see-- what's the incentive to change the way policy is made so that the investment is made in technology? And so that some of the hard choices about perhaps having more expensive energy actually get done?

MONIZ: Well, in terms of that lack of faith. I think I expressed the same in a different way by saying that we need to lower the costs so that making those policies is a lot easier, politically, than with, frankly, with today's premium for low-carbon approaches. So I believe, again, cost reduction in the technology may have to lead some of the policy developments.

Now, a second thread is that I certainly believe that the scientific understanding of climate change is such that, while not arguing that all issues are resolved and understood in what is a very, very complex situation, that the case is made for being prudent. And prudent means getting on the pathway of accelerating decarbonization, particularly because many of the steps one takes for that purpose have other very, very important positive consequences. So, going to low carbon often means-- typically means-- going to lower conventional pollutant emissions. For example, earlier I mentioned the substitution of natural gas for the oldest, most inefficient coal plants. Those old inefficient coal plants are going to be under a lot of pressure anyway as clean air rules get tightened over this decade. So that's another factor that pushes in that direction.

Another factor is that when we talk about energy security issues, particularly involving oil, I would remind one that that's carbon. So in moving towards decarbonization, one is also taking steps that generally improve one's security of energy supply. Because after all, security of supply involves natural resources dug out of the ground. It doesn't involve wind, sun, and frankly, nuclear power-- sure, uranium is dug out of the ground, but it's such a small part of the cost of nuclear power. We also have a lot of uranium in Canada and Australia and the United States. So the decarbonization move supports not only climate, but other environmental objectives. It supports energy security objectives. So there are many, many reasons, I think, that support putting together the kind of policy we're talking about.

But reduction of cost for low carbon would be important. And secondly, there is one major piece that has to be addressed politically, and it's difficult. And that is, again, the differences in regional needs and energy sources in the United States. Some regions, obviously, in the country depend upon coal. Coal mining, coal utilization. Other parts of the country have renewable resources that are not uniformly spread across the United States. So I think we have not also politically managed this distributional problem, if you like, of reflecting the different needs in different parts of the country. But, to ameliorate on that side, I would point out that when one looks at the higher energy costs that would, undoubtedly, result from an acceleration of low carbon deployment, certainly if that is done in an economically sensible way, one should not conclude that GDP is materially impacted.

In our modeling here, we did a recent study, for example. And in our modeling, what we find is that a 50 percent reduction of carbon dioxide emissions to mid-century reduces energy demand substantially, one of the two major pathways we need to take. It changes the GPD in 2050 from 3x to 2.9x, which is essentially irresolvable at this stage. But two caveats. One is that that presumes that the funds, let's say, associated with the higher energy costs, are recycled into the economy with perfect efficiency, which may not be exactly the political reality. And secondly, while the macroeconomic numbers are not changed much, we still have the distributional problem that there are winners and losers. So that's where the political grappling has to occur. But again the encouraging aspects are the fact that one has many additional benefits besides prudence on minimizing climate risks. And the macro economy is not strongly affected.

And third, of course, comes the unknown as to the extent to which we will see additional changes in the climate that more and more reinforce the expectations that we have today from our current understanding. And I think there's no question that while one cannot today associate every individual event-- a hurricane-- with warming, it is true that the pattern of changes anticipated quite some time ago does seem to be, on average, materializing.

So all of these things must come together. It will be a challenge. We will certainly need in the international arena to, I think, maintain and sustain the kind of direction that was taken in the Copenhagen Accord, which is a very, very strong differentiation about the timing and responsibilities of industrialized countries, emerging economies, and the less developed countries.

INTERVIEWER: It sounds like there's a bit of a catch-22 in this. In that for the technology to advance as rapidly as it needs to given the time frame of the current crisis, you need the additional investment from outside. But you're not going to get the additional investment until the technology's advanced and made it all cheaper. Or am I misinterpreting?

MONIZ: No, I think that there is an understanding that we need the investment to accelerate the technology development and the associated lowering of costs. We do have, however, the budgetary constraints. There's no question about that. I personally think that there are two ways of thinking somewhat more optimistically about the resources required to make these changes.

First, it's not only government. We also have industry, and I think the industry, as we see here at MIT where our energy initiative has 15 essentially corporate members who are sponsoring research. We are still seeing the large energy companies investing in a diversification of opportunities for the future. I mentioned earlier that Eni, their investment here is in-- major investment is in solar. BP, their major investment here is in advanced coal conversion with carbon capture. And I could go through others. The point being that these companies are making investments here which are not really today's core business. But they are positioning for a changed portfolio in a low carbon world. So I think that we should not forget that we see industry still committed to this broadening of the portfolio. I think for good business reasons.

Now going back to government, which is certainly essential. In my view, we will not see large substantial increases in funding over the next years in the conventional approach, in which Congress year by year appropriates funding. I just think the numbers don't add up. We just don't have the flexibility in the discretionary budget over the next several years, certainly not until the economy is much more robust and deficits are reduced, et cetera.

However, that is not the only way to fund the research. We have historical examples, and we even have an example today in which research is funded, often in partnership with the private sector, through some very, very small charge on energy use. For example, historically there was something called the Gas Research Institute. It managed over $200 million a year of funding just in natural gas areas through a very small surcharge that was approved by the federal regulatory body, FERC, and was charged on all interstate gas transmission. And then was managed by this nonprofit 501c3 organization for research. So there are these, if you like, off-budget approaches which I think are gaining more and more attention, perhaps because we can't afford to appropriate the funds.

So to give you a scale, suppose we were to have a charge of 1/10 of $0.01 per kilowatt hour on electricity in the United States. One mill. I cannot believe that anybody would notice that in an individual bill. You know, it's roughly 1 percent of what one is paying for electricity on average. Well one mill per kilowatt hour, if that were somehow to be collected and to go into a fund to manage research, let's say on low carbon electricity. Well that would be $4 billion per year. We're talking about the right scale. Okay, so we will see. It's not politically simple to do. But I think it's getting much more attention as a way to generate the kind of investment we need and it makes sense. It's like taking-- it's like what a company would do. You take a small fraction of your revenues and you reinvest them for your future. And so we're asking, in a certain sense, the government to think about it in the same way.

INTERVIEWER: Can you talk about MIT's Energy Initiative and its goals.

MONIZ: The MIT initiative's goals are to facilitate programs and projects in research and education for our faculty and students, to allow them to make contributions to solving these big problems. So, in the energy initiative, first let me say that-- well, first let me say that we have fantastic support from the highest levels of MIT and, most specifically, President Hockfield, who really launched the initiative in her inaugural speech at MIT. And launched it in a way that set its character, for example, by emphasizing right from the beginning that all five schools were to be involved, which is very important. I mean, clearly, engineering, the engineering school has an absolutely core role in terms of technology development et cetera. And science.

But President Hockfield identified immediately that if we don't also have business, management, economics, political science, architecture, planning involved, we could not get the solutions at the scale we want. So that was a very, very important point. And today, we have roughly 25 percent of all of MIT's faculty, in one way or another involved at one time or another, in the energy initiative. So I think there's no question about the dedication of our faculty and our students to wanting to help with this problem. I mean, I think many see it as the overarching challenge in the end for the next many, many decades.

So our job at the Energy Negative is to first of all, facilitate research. Particularly the research that brings together faculty from different departments and schools. We view that as something of a value added, if you like, and I think we have been successful in working with the faculty to realize many major research programs at that time.

We seed new projects. We've been really very fortunate that we've been able to provide significant funding for 63 projects which are early stage new ideas. And very importantly, roughly half of them are bringing into the fold, if you like, faculty who have world class capabilities but have never applied them to energy- related problems. So I think this is a tremendous source of creativity and new ideas. We have been able to provide graduate fellowships for about a 125 students, most of them first year students, to attract into energy-related activities. And those fellowships are completely awarded by the departments.

We have a very, very active educational committee under the leadership of Professors Belovich and Lessard from engineering and Sloan. They and a group of about 10 faculty have now instituted the first institute-wide minor degree program for undergraduates in energy. This is very, very exciting. It's completely novel. New courses have been developed in science and engineering and in management and humanities as requirements for this minor in energy. We eventually will see textbooks published, we will see open courseware propagating this kind of approach elsewhere. We have a very active task force under the leadership of Professor Glicksman from architecture and Terry Stone, MIT's senior vice president and treasurer. Another interesting construct with administration and faculty co-leading a group looking at campus energy management, basically, weaning of the campus. But with a strong focus on providing research opportunities on the campus, energy efficiency projects, et cetera, which has been very, very successful so far.

And fourth, we have a direct responsibility as well to help bring to bear the talents of MIT on the policy debate. It's a major part of our outreach program. And I think, once again, we have seen a step up in terms of integrated analysis of technology and policy. In terms of faculty testifying before Congress and bringing what we believe is strongly analytically based information to the policy debate.

So it's quite broad-- again, research, education, graduate training, campus energy, and policy outreach. We've been-- the core of our support has come from industry. However, now over the last year and a half, there's been an enormous increase in also focused government-sponsored programs. In basic science underpinning energy technology. In moving technologies from laboratory to market orientation. So that's been a new direction. And finally, alumni and friends' very generous giving have helped support many of these activities. In education, we've had two major gifts to advance these new courses that cut across boundaries. On campus energy management, we've had two major gifts to help create, for example, a revolving fund for implementing energy efficiency projects. So it's been a tremendous community-wide effort where the community is MIT today MIT distributed in terms of friends and alumni.

INTERVIEWER: Can you talk a little about the years you spent working in government? And how that relates back to MIT, that maybe the benefits of lending someone out in that way?

MONIZ: I think my years in government service were very, very interesting. And I think have certainly strongly colored my reentry into MIT and what we are doing today. I believe-- and we can discuss some of the benefits, I think, that come from allowing faculty to make appropriate contributions in government. But I think I would first start by something that was instilled in me and in many others from our first years here. And that is, more important than the benefits, I think, is the responsibility of an institution like MIT to help in the public discourse, and in the operations of our government.

Certainly when I came here 37 years ago, the president was Jerry Wiesner who I think very much had this idea that it was a responsibility to do this. But then I had a mentor here, Herman Feshbach, who was absolutely passionate about it. And roughly speaking, forced me to take part in a national study on a public policy issue when I was an untenured junior faculty member. The argument that I used-- that I was a junior, untenured faculty member did not impress him. And so he felt there was no reason why one couldn't do two jobs at once. And I did and I was quite happy for it in the sense that it gave me a bit of a flavor of getting involved in these issues.

So then we go forward many years after that and, again, by being involved in the formulation of what was in effect research policy, that then led to my first stint in the government, which as associate director in the Office of Science and Technology Policy, colloquially the President's Science Adviser's Office. And there, I had responsibilities for the physical, life, and social and behavioral sciences. So in terms of benefits, I think it certainly exposed me to a set of issues well beyond my previous remit. And there I had responsibility within the office for higher education and a lot of policies involving higher education. And so I think that was really-- it gave me a new perspective, frankly, looking from the outside in some sense to the academy. And what it meant to have effective interactions with and support from the government.

When I returned from that position and resumed as department head in physics, again I did have a new perspective. But it didn't last very long, because I kind of turned around and went back as Undersecretary of the Department of Energy. And there I had very broad responsibilities because, actually, in those days, there was only one undersecretary, which means for the Department of Energy that was looking over the basic science programs, the Department of Energy, not often recognized as the largest supporter of research in the physical sciences of any organization I think in the world, actually obviously, a major role for the energy technology programs. Third, a role in nuclear weapons and nonproliferation world, which was a very major issue in the '90s as Russia had collapsed and we had major responsibilities at the department for securing weapons materials. And then we also had environmental remediation responsibilities.

So this was very interesting and a very, very challenging agenda in terms of-- if you want a narrow definition of the benefits to MIT-- well, as I said earlier, for better or for worse, that experience led me to come back and to totally change my research orientation into energy technology and policy, which, perhaps a few years later, proved rather serendipitous in terms of aligning with the energy initiative that the new President Hockfield emphasized strongly. So again, it's a bit of a random walk, perhaps, but I think the perspective that one gains, I think the fulfilling of a public responsibility of an institution like MIT, and the opportunity then to influence programs back at the Institute, I think, are all pluses. And I'm pleased to see when I think MIT faculty continue this tradition of helping in the public arena. It can be disruptive to one's career. One cannot deny that. But I believe it's an overarching responsibility. And today I might say I'm kind of back in the saddle in the sense of, even though now I'm not paid for it by the taxpayer, in unpaid advisory positions in the new administration.

INTERVIEWER: So are you telling President Obama to invest more in technology research?

MONIZ: Absolutely. Every chance I get.

INTERVIEWER: From your five, five and a half years of government service, what did you learn that people would be surprised about?

MONIZ: One thing people would be surprised about, given the usual discourse about public servants, is that people work very hard for the taxpayer. I really think that's a very important point. And there are a lot of talented people who are working in a difficult environment, with a lot of constraints on them. So I think that actually is something that I wish the public understood better that there are lots of talented and dedicated people really working at these jobs.

Second thing is clearly how hard it is to get something done. It's so much easier, of course, to not do something than to actually do something. But then again that emphasizes the importance of understanding where different people are coming from, because in the end, politics is about finding-- again, not the perfect solution, but the solution that satisfies enough different needs and perspectives. I think that's a valuable lesson, actually, anywhere one is working. Certainly including a university. But I think one kind of senses that, but I think it's different, frankly, when one is on the inside and understands the difficulty of finding a position that has-- that can attract enough support from disparate sources. So I think that's actually quite important.

And then I think, in addition, one learns a lot about specific subject areas. I mentioned earlier when I was there-- one certainly cannot set one's own agenda according to one's preferences. Let's face it, one is somewhat hostage to whatever the issues that come up are. And certainly when I was there, I spent a huge amount of my time-- there being the Department of Energy-- a huge amount of my time was spent on the international nonproliferation problem. Because that was hot at the time. And we had a national challenge in terms of particularly helping Russia to secure nuclear materials in our own interest. Well I learned a lot about international negotiations, about the technologies, about how one works across very, very different cultures to accomplish a common goal. And it was a common goal. Certainly the scientists we worked with, and I would say in general, the government officials we worked with in Russia, did have a common goal. They just had a very, very different view as to how to get there. But so there was a tremendous amount to learn.

INTERVIEWER: A lot of your work has been in collaboration with industry as well. And you're an advocate of that sort of academic industry collaboration. Can you talk about the benefits of that and why it's so useful?

MONIZ: I'm a major advocate of this collaboration with industry-- I should say first, specifically in the area of energy. And there are several reasons for that. But probably the overarching one is that I believe, personally, that the kind of acceleration of the low carbon transformation at very large scale can only occur when we somehow marry more effectively than we have in the past the academic, the entrepreneurial, and the large energy company cultures.

The first two, the academy and the entrepreneurial culture-- certainly for MIT, we don't have a big challenge in marrying those. I think we've been in the forefront of that for a long time, which gives us a big leg up. And the amount of entrepreneurial activity going on in the energy technology sector is unparalleled today. And I don't mean only at MIT, clearly. At MIT, it's also, I think unparalleled. But nationally and globally, it's unparalleled. However translating the results of that entrepreneurial culture into scalable solutions in a short time is a challenge that I think we've not faced before. And one that again, I believe, is going to require-- I guess at MIT we can use impedance matching between that culture and the energy business culture.

I say that because the energy business, when all is said and done, is not only enormous in scale. You know, it's a multi-trillion dollar a year business. To do things in the energy sector typically requires enormous amounts of capital. It's a highly capitalized business. It is, in a fundamental sense, a commodity business. That is, when you-- again, when you flip on the light switch, whether that electron was generated by a coal plant or a photovoltaic doesn't affect the fact that it produces light. In fact, energy generally is about lighting, heating, mobility.

And the great new inventions that we are making and will make to supply those services in different ways is still fundamentally providing the same services. That makes it very cost sensitive, as opposed to paying a premium to get a brand new service. Something you could not do before, mostly in energy, you are just providing a different way of giving you the same services. And then lowest cost becomes a major issue. The services provided are essential for everything we do. That means the business is, and will always be, highly regulated. Huge customer bases. Incredible supply chains, which are, of course highly tuned because of the low cost requirement. You put all those things together, that is not the definition of an area ripe for innovation in the traditional sense. And that's why I say that there is this kind of impedance matching we need.

So in the end, I believe that these energy companies in fact, are absolutely core to the transformation away from, in a sense, what they're doing today in their business. And so, it was our view that we would in fact build our initiative around that. Now clearly there are other-- obviously, there are other reasons. I mean, the energy companies of scale are also those who support research at some scale. Frankly, they also have a charming habit of actually making decisions one way over the other. So, you know, in our view, there were multiple reasons that this was a good first focus to build the initiative. But always with the idea in mind that we were working with the people who, in the end, have to be core to the solution of the real problem.

INTERVIEWER: So in a sense, you're saying that they are the most motivated to find a solution and transform?

MONIZ: Well, I mean, I think the entrepreneurs are strongly motivated. You look around here at MIT. I mean, people are doing-- are working in this, many of them changing their research not just because they view it as an opportunity to spin out a company and make some funding. They can do that in multiple areas. They do feel that this is an overarching challenge to bring science, engineering, management, planning talents to improving the human condition. But-- so it's not exclusive. But these large companies also have a strong internal motivation. You know, it's very uncertain in the end, really, how and when this large energy system will evolve.

And I think there are good business model reasons for the kinds of investments that they are making. I still believe that for almost everyone, including the large energy companies, believe that carbon constraints one way or another are coming. Whether they come through an explicit climate policy like cap and trade. Or through other means-- regulation, a collection of energy policies that have the consequence of pushing towards low carbon-- I believe that these companies feel it's coming. They don't know quite when, they don't know quite how fast. And I believe, again, there are good business model reasons for the kinds of investment they are making with us in terms of building options in their portfolio. And good reasons for us to be interested in developing these new technologies that can be transformative.

INTERVIEWER: So let's talk a little bit about MIT. Why have you stayed here so long?

MONIZ: Because it's the best place to be. And I would say, I've had a number of opportunities to change venue, including to other excellent universities. But I just find the environment here-- the problem solving mentality, the creativity, sometimes in rather interesting ways-- of our faculty and students to be an environment that I just find to be exceptional. And so I really-- I've enjoyed my wanderings, like into government, for example. But in the end, I just find this the best fit, at least for me, in terms of having a sense of continuing challenge and continuing contribution.

INTERVIEWER: How would you describe MIT in terms of what makes it unique? I know you've said some of these things before. But how do you see it being different than any other place?

MONIZ: Well, I think MIT is different in its history. We've talked about, for example, my personal view that interacting with industry is so critical in the energy business. Well, who has a longer history of interacting with industry and viewing that as a good thing to do. I mean, it's in our genes. It's in our founding charter. I think, you know, we were not called institute as opposed to a university for no reason back in the 1860s. So there's that. There is the history, certainly at least since the post-World War II period, of working across boundaries. Well again, in the energy business, you have to work across these boundaries to have scalable solutions. So there are these kinds of institutional reasons that certainly fit very, very well with my personal priorities and commitments.

But when all is said and done, it goes back to the other statements about-- I just find the quality and the creativity of the students, especially the students, but of the faculty as well here, with a strong focus on give me a problem. Define a problem, and I'm going to solve this problem, to just be tremendously invigorating. And I honestly don't believe that that same attitude permeates the cultures of other universities as completely as it does here. Again I'm-- there are many great universities and there are many faculty at those universities who share this kind of view of the world-- but I just think here it is kind of the dominant philosophy. It's nurtured, it's appreciated, and well, what can I say? I really like it here.

INTERVIEWER: In your 37 years, what kinds of institutional changes have you seen? In the students, in the faculty, in the culture?

MONIZ: Well, you know. I think we see a lot of changes that are obviously reflective of what's going on in the outside world, certainly in terms of technology. It's pretty clear that the technology that we take for granted every day is very, very different from what it was 37 years ago. But you know, to be honest, I feel it's more the constant threads over those 37 years. As I've said, that I really appreciate. I mean today's students-- for example, it's great to see the very, very different demographics of our students, our undergraduate students, women, minority students. I think it's a much richer cultural environment in that sense. But I don't see the students as being different from the point of view of talent and of this-- I mean, they're here because they are interested, I think, in this same kind of problem solving approach. So I think it's a great mix of a different demographic but a fundamental, I think, same dedication.

And our graduate students, certainly from when I started here. Once again, the demographics are quite different, particularly in terms of international students in addition to gender, for example. And I think that that's frankly, a plus in terms of a richer environment. Now we do have some challenges in that domain which are visited from the outside. And which I think is a very counterproductive set of barriers that have been set up in terms of many international students coming here over the last decade. But I think we'll work through that. And again, I think that it's same theme, different demographic, same fundamental level of talent and of commitment to solving real problems.

INTERVIEWER: Are you talking about it being more difficult to come here as a graduate student?

MONIZ: Correct. I'm talking about the visa issues that have arisen since 9/11. And I think that no one is arguing that we don't want to have sensible policies that reflect security realities. But I do think that we are often cutting off our nose to spite our face, that we are providing unnecessary barriers. And in my view, what I very much dislike, is the idea that once a student has in fact satisfied the national imperatives in terms of getting a visa, once they are here, we need to have a completely open and transparent system in which everyone participates in everything without complicated restrictions.

INTERVIEWER: I didn't actually realize there were restrictions once people got here.

MONIZ: Well, there are a variety of issues in terms of things. Arcane issues like deemed exports in which certain nationals should not be exposed to certain technologies even though we use them all the time in our work. So I think there are complications. I think we will work this through over the next decade. But I think for the moment, I think it is hurting, somewhat, the functioning of the academy.

INTERVIEWER: You've had some experience in administration at MIT. How did that experience, as a department head, for example, did you find that you were able to accomplish things that you hadn't been able to do? Or did you find it frustrating?

MONIZ: My principle is to enjoy everything I do. So I did 100 months as director of the Bates Laboratory. I did five years as department head. Now I'm, I guess, four years into the energy initiative job. As department head, I thought it was actually challenging at times. We had a large Department of Physics. Not everyone was a shy and retiring chap, shall we say. Nevertheless, I think there were opportunities to do important things. And frankly, I think, if I would single out one thing in that period is that we were able to accelerate the move of our faculty to full academic year salary support and funding, which I think was a major change in how the faculty could approach everything they do in terms of having secure funding. And the administration at that time was certainly supportive of moving in that direction. We rather fast-tracked it. And so that was actually a very important, I think, kind of cultural issue.

I think it was also-- as department head, one can help shape with the faculty new research directions according to hiring of young faculty. And that was tremendously exciting. And then, for example, in my last stint as department head, to show how things kind of go around, I provided some seed funding to Professor Belcher to develop what eventually became TEAL, the Technology Enhanced Learning Approach for physics. And I remain-- you know, it's had its rough spots coming in. But I think it is absolutely the right way for us to go. But what comes around is, I gave that seed funding, wandered off to the government for many years, and came back just in time to have the very first 802 full implementation of TEAL. And needless to say, I was therefore told I had a responsibility to be one of the faculty teaching in that. And I had a great time doing it. So anyway, I think it's-- INTERVIEWER: Poetic justice in that.

MONIZ: Yes. And it was great. I mean, I actually, I enjoyed it.

INTERVIEWER: What do you consider the great strengths of the physics department?

MONIZ: The faculty and the students. That's very easy. The department has been self-perpetuating, if you like, as certainly a premier-- various rankings have it number one, whatever that means-- as a department. But one of the things our Department of Physics, I think, has managed to use effectively as a strength, its size. So that we do have a great diversity of programs. And I think that's been very important. I think another strength of the department flows from the fact that all undergraduates at MIT have a year of physics. And I think that's very enriching for the department to provide, what is sometimes called a service. But I look at it as an opportunity to really intersect with students who have all kinds of different interests.

Another strength, I think, is that the department has been committed to renewal through junior faculty hiring over the years. Some other institutions tend to favor more recruiting at the senior level. I think the department-- and actually it's true of MIT more generally-- but I think the department has benefited enormously by sticking to the fundamental priority of bringing in junior faculty and helping them to develop. When I was department head, I always like to say that showing great wisdom, my last hire was a junior faculty member who-- I had a choice between two candidates-- was a faculty member that went on to win the Nobel Prize. What a great choice. Except the other candidate shared the Nobel Prize with him. So those are the kinds of choices that are great to make at a place like MIT.

INTERVIEWER: So that was a no lose situation. You could have hired the other person.

MONIZ: That's right. But I have my version of the facts.

INTERVIEWER: When you think about your research or teaching or the government work or the work with industry, what contributions are you most pleased about?

MONIZ: It's very hard to answer that question because I think they all fit together into a consistent whole. Right now with the energy initiative, I think the-- and I should say with my colleague Bob Armstrong and a very, very talented and very small I might say, staff, I think what gives us the greatest pleasure is the fact that we have been able to facilitate the work done by other faculty in terms of some really stunning new developments in energy, science, and technology and planning. And at the same time have facilitated the development of these genuinely new curriculum options in energy. Options that don't exist anywhere else at the moment. So I think in the end, that's the most important thing. And that brings together all those threads. Industry providing support, faculty with new ideas, the students being creative, faculty with novel ideas about teaching. Again, it's just part of a fabric, I think, that really has to have all the threads, you know, intertwined.