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A REVIEW OF NUCLEAR SAFETY IN LIGHT OF THE IMPACT OF NATURAL DISASTERS ON JAPANESE NUCLEAR FACILITIES

HEARING

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON APPROPRIATIONS
UNITED STATES SENATE

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WEDNESDAY, MARCH 30, 2011

U.S. SENATE,
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT,
COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 10:02 a.m., in room SD–138, Dirksen Senate Office Building, Hon. Dianne Feinstein (chairman) presiding.

Present: Senators Feinstein, Lautenberg, Durbin, Alexander, and Graham.

OPENING STATEMENT OF SENATOR DIANNE FEINSTEIN

Senator FEINSTEIN. Good morning ladies and gentlemen. And welcome to the Energy and Water Appropriations Subcommittee's Oversight Hearing of U.S. Nuclear Power Safety in the aftermath of the Japanese nuclear disaster.

First, let me say, on behalf of the subcommittee, that our thoughts are with the people of Japan who continue to suffer. I spoke to Ambassador Fujisaki Saturday and conveyed my really deep sympathy. I think for all of us who have been watching this on television, day after day and through the horrors of both the earthquake and the tsunami that we want to extend our very best to the people of Japan and our deepest sympathy for what is an enormous loss.

The 9.0 earthquake and resulting tsunami occurred 19 days ago. As we speak, workers at the Daiichi nuclear site continue their work to contain the situation with the reactors and spent-fuel pools. They have been called national heroes and so they should be.

It will be months before we know what happened and why. So it is too early to call this a hearing about lessons learned from the disaster in Japan. But we do know enough to start asking some critical questions about nuclear energy policy in our own country.

Last week I visited California's two nuclear power plants with representatives from the United States Geological Survey and the Nuclear Regulatory Commission (NRC). The Diablo Canyon Nuclear Power Plant is near the city of San Luis Obispo, it is one of the largest employers in the county. Four hundred and twenty-four thousand people live within 50 miles. It employs 1,200 people. Further south, nearly 7.4 million people live within 50 miles of the San Onofre Nuclear Generating Station near San Clemente.

I came away from those visits with some good news. I feel much better about the safety precautions that are in place at these nuclear plants. I was very impressed with the dedication, the confidence and the professionalism of the large staffs that run these facilities and the regulatory agents who guard against risk.

But we need to reconfirm that these facilities are designed to endure the threats we can foresee and prepared to respond to scenarios we never imagined, that's why redundant systems, back up systems and plans are so important.

Most significantly, I truly believe we must begin to rethink how we manage spent fuel. Spent fuel must remain in pools, and those are the pools that the firemen are pouring water into in Japan, for at least 5 to 7 years at which time these rods can be moved to safer, dry cask storage. However, these pools often become de facto long-term storage, with fuel assemblies re-racked, thus increasing the heat load of the pools. In California, for instance, fuel removed from reactors in 1984 is still cooling in wet, spent-fuel pools.

This process may have regulatory approval, but I have a hard time understanding why the NRC has not mandated a more rapid transfer of spent fuel to dry casks. Reports out of Japan indicate there were no problems with the dry casks at Daiichi. To me, that suggests that we should at least consider a policy that would encourage quicker movement of spent fuel to dry cask storage.

We must also consider what broader regulatory reforms may be necessary, beginning with the review of the United States power plant safety. I am very pleased that the NRC will undertake both short term and long-term reviews of nuclear plant safety. Chairmain Jaczko, I thank you very much for that. This kind of self-reassessment is really appropriate. Today, I hope we will get a more complete picture of what the NRC intends to do with these reviews and how quickly you are likely to act on any new safety regulations.

In addition to NRC's self-assessment, I think we should take a look at some independent analysis of our nuclear power plant safety, with specific attention to threat assessment and the design parameters of our plants.

Japan has now suffered two earthquakes in the past 4 years that were larger than the Japanese thought possible and each devastated a nuclear power plant that was not designed to endure a quake of that size. The lesson is that we need to think carefully about whether our country has properly estimated the threats to our nuclear facilities and designed the facilities to endure them. An independent review of the design basis for all U.S. plants, I believe, should be a priority.

The nuclear R&D program currently funds work related to existing plants, future reactor designs and waste issues. The question becomes: Do we have the right focus and balance to promote increased safety?

The spent fuel at Daiichi posed a significant problem, contributing to at least one of the hydrogen explosions. So, what can our R&D programs do to address issues of remaining spent-fuel energy and hydrogen?

Funding constraints are already requiring programs to rerank R&D priorities. Perhaps the events at Daiichi will also contribute to that rethink.

It is clear that we lack a comprehensive national policy to address the nuclear fuel cycle, including management of nuclear waste. Creating more waste without a plan increases our risk and exposes taxpayers to more payments from utilities.

This hearing is not focused on nuclear waste, but I think it is hard to look at the other aspects of nuclear power and not recognize our lack of appropriate, permanent, retrievable storage.

So, we will be exploring these issues today. On our first panel, we will hear from Greg Jaczko, the chairman of the NRC. I have had the pleasure of meeting with him and look forward to his testimony. We will also hear from Pete Lyons, the Acting Assistant Secretary for Nuclear Energy at the Department of Energy (DOE).

Our second panel will include Dr. Ernie Moniz from the Massachusetts Institute of Technology (MIT) who has a long history in this area and is currently serving on the Blue Ribbon Commission developing a long-term plan for nuclear waste. We will also hear from William Levis, the president and chief operating officer at PSEG Power. PSEG operates the same reactor model as those at the Daiichi site. Our third witness on the panel is Dave Lochbaum from the Union of Concerned Scientists. Mr. Lochbaum has a long history inside and outside the nuclear power industry. So we look forward to your testimony.

Let me now turn to my distinguished ranking member, with whom it's a great pleasure to work. We have actually worked together in the prior session on the Interior, Environment, and Related Agencies Subcommittee. And I think this is our first hearing on this subcommittee.

So, I want you to know I very much look forward to working with you in the same way we did on Interior.

OPENING STATEMENT OF SENATOR LAMAR ALEXANDER

Senator ALEXANDER. Thank you, Madam Chairman. Thank you for that and thank you for hosting this hearing in a timely way and having the witnesses here whom we ought to be hearing from—people who know what they are talking about and are in charge of the safety and usefulness of our nuclear program.

Those of us who support nuclear power as a part of the mix of electricity generation in the United States, and for the world, ought to be among the first to ask questions about what can we learn from what happened in Japan, about the safety of our own reactors: the 104 commercial reactors that we have in the United States; those that are on the drawing board at the NRC; and the large number of nuclear reactors in our nuclear Navy which have been operating since the 1950s.

The questions I will be looking forward to hearing more about are similar to those that Senator Feinstein mentioned. What kind of safety enhancements have been made at our current nuclear plants since they have been in operation? How will the safety capabilities of the next generation of reactors improve over reactors that are in service not just in the United States, but around the world today? What about new technologies? One of the most important things that the Federal Government can do about clean energy is research. We have the capacity for that.

I was in Great Britain for 3 days last week and they reminded me that we are the ones with the national labs; we are the ones with the great research universities. And if any country is going to have advanced research in clean energy, it ought to be the United States. We could do that for ourselves and for the world. And nuclear power is one area where we could do that.

The chairman has mentioned one area of advanced research, which is improving the way we recycle used nuclear fuel. Another would be research on small modular reactors (SMR). Can we build 125 megawatt reactors or smaller reactors as a part of our future? So those are the kinds of questions that I will be looking for in this hearing.

I thank the chairman for reminding us of the scope of the Japanese tragedy. It is important to put the entire event in perspective in several ways. One way is to look at the size of the quake and the size of the tsunami and the size of the tragedy. There are hundreds of thousands of people, for example, still homeless in Japan. And just like California, by its proximity to the Pacific Ocean, Tennessee has an unusual relationship with the people of Japan because over the years we have become the State with the most Japanese manufacturing, and we are home to many Japanese families and friends, so we have felt this tragedy even more than we might otherwise have.

Another way to put this tragedy into perspective is to be aware of the record of safety in the United States' nuclear industry. The only deaths we have ever had in connection with reactors in the United States happened in 1961 at a research reactor, and that that kind of reactor isn't used anymore in our country. The 104 civilian reactors we have in the United States have never produced a fatality. The Navy ships that have been powered by nuclear reactors since the 1950s have never resulted in a fatality from a reactor accident.

And while we have heard a lot of comparisons with Three Mile Island—the worst nuclear accident we have had in our country, I suppose—no one was injured as a result, which many people don't believe when I say it.

So the nuclear industry has a safety record in the United States that is not surpassed by any other form of energy production. We unfortunately have coal mines that blow up, gas plants that blow up, and oil rigs that spill, all of which are tragedies and we hope that we continue a good safety record in our nuclear plants.

I think it is also important to keep in perspective what our alternatives to nuclear energy are. Every form of energy we have carries with it some risk. Again, in listening to those talking in Great Britain this past week, they are going through the same sort of analysis. But they have few alternatives. Forty-five percent of their electricity comes from natural gas, which costs twice as much as ours does. One-half of their supply comes from Russia, and they are not sure that they want to increase that to 80 percent. They are closing their coal plants because of their climate change rules. And they know that renewables can only provide a fraction of intermittent electricity which takes up a lot of space for an island that doesn't have very much space. So their only option is to build more nuclear power plants, which is what Great Britain is planning to do.

And as we look around the world, we see that nuclear power provides 15 percent of the world's electricity, including 30 percent of Japan's electricity. There are 65 reactors currently under construction worldwide, from Russia and China, to Brazil and Korea; 20 percent of our electricity in the United States comes from nuclear power; 70 percent of our clean electricity—that is sulfur, nitrogen, mercury, and carbon-free—comes from nuclear power. So it is hard for me to imagine how we have a future in the United States without substantial expansion of nuclear power, especially since some coal plants are going to close and some nuclear power plants are going to close because they are old.

So that makes this hearing on what we can learn about safety even more important. I thank the chairman for holding the hearing and I look forward to the testimony of the witnesses.

Senator FEINSTEIN. Thank you very much, Senator, for those excellent comments.

Senator Lautenberg, welcome. Would you like to make a brief statement?

STATEMENT OF SENATOR FRANK R. LAUTENBERG

Senator LAUTENBERG. Yes. I'd like to make a longer one, but I will make this brief, I think. Just to say, Madam Chairman, this not only obviously is timely, but we are pleased to have Mr. Jaczko here. I had the chance to meet with him yesterday and I think we—the review we had was very productive and I was—I will also attest to Mr. Jaczko's durability, not only his engineering skill, because he came in from Japan and I was—had to speak coming from New Jersey, so we welcome you here again, to both witnesses. And I look forward to hearing from them. And I thank you, Madam Chairman for having the hearing.

Senator FEINSTEIN. Thank you very much, Senator.

Chairman Jaczko and Dr. Lyons, thank you both for being here today, you have both been intimately involved with the crisis and as Senator Lautenberg said, I understand you just returned, Mr. Chairman, from Japan, so we would be most interested in your observations and update on that situation. But, I also want you to be looking forward and talk a little bit about the issues the United States should consider in learning from this event.

Your formal statements, gentlemen, will be made part of the record, so please summarize, in your oral statement.

Mr. Chairman, we will begin with you.

STATEMENT OF HON. GREGORY B. JACZKO, CHAIRMAN, NUCLEAR REGULATORY COMMISSION

Mr. JACZKO. Thank you, Chairman Feinstein, Ranking Member Alexander and Senator Lautenberg.

I appreciate the opportunity to appear before your subcommittee today to address the response of the NRC to these tragic events that you have discussed, in Japan. And as you have mentioned, I traveled to Japan over the past weekend and just returned yesterday. And I want to be able to directly convey a message of support to our Japanese counterparts. And I had an opportunity to meet with senior Japanese Government and TECPO officials and I consulted with the NRC team of experts who are in Japan as part of our effort to assist the Japanese response to dealing with the nuclear reactors. And I would note that that is one small part of a broader United States effort to provide assistance to the Japanese with regard to all of the challenges they are facing as a result of this hurricane and tsunami.

And as many of you have mentioned, I too would like to reiterate my condolences and sympathy to all of those who have been affected by the earthquake and the tsunami in Japan. Our hearts go out to all of those who have been dealing with the aftermath of these natural disasters and we are mindful of the long and difficult road they will face in recovering.

Since Friday, March 11, when the earthquake and tsunami struck, the NRC's headquarters operation center has been operating on a 24-hour basis to monitor and analyze events at nuclear power plants in Japan. Despite the very high level of support being provided by our agency in response to those events, we do continue to remain focused on our domestic responsibilities and ultimately ensuring the safety and security of the U.S. nuclear reactors.

In spite of the evolving situation, the long hours and the intensity of efforts, the NRC staff has approached their responsibilities with dedication, determination, and professionalism and I am very proud of the work that they have done and the work that they have done as part of a larger U.S. Government effort.

On March 11, as you have mentioned, an earthquake hit Japan resulting in the shutdown of more than 10 reactors in Japan. The tsunami that followed appears to have caused the loss of normal and emergency electric power to six units at the Fukushima Daiichi site. After this event we began interacting our Japanese regulatory counterparts and by the following Monday we had dispatched a total of 11 NRC staff to Japan.

Now, as our discussion and understanding of the events continued to unfold, at a certain point we gained a limited amount of information that led us to believe that there was a possibility of a further degradation in the conditions at the reactor. Based on the information that we had, we looked at that situation, relative to what we would do here in the United States and we determined that if a similar situation were to happen in the United States, we would be recommending a larger evacuation out to approximately 50 miles. And I would stress that that was based on limited information and was a conservative and prudent decision that was made. So based on that information we provided a recommendation to the United States Government and the ambassador in Japan issued a notice to American citizens in Japan to be advised to evacuate or to relocate to 50 miles beyond the plant.

Here, domestically, we continue to support efforts to monitor at nuclear power plants and through the Environmental Protection Agency's system, we continue to monitor radiation levels that would be seen in the United States. And I want to stress and repeat that we do not believe that there is any likelihood of levels of radiation in the United States that could cause any kind of public health and safety concern.

Now I want to focus a little bit, with the remainder of my opening remarks, on the reasons we believe we have a strong regulatory program here in the United States. Since the beginning of our regulatory program we have emphasized the philosophy of defense in depth which recognizes that nuclear reactors require the highest standards of design, construction, oversight, and operation. And it really does not rely on any one single layer of protection for public health and safety. Designs for every reactor in this country take into account site specific factors and include a detailed evaluation for natural events, such as earthquakes, tornados, hurricanes, floods, and tsunamis. There are multiple physical barriers to radiation being released to the public in every reactor design. And additionally, there are diverse and redundant safety systems that are required to be maintained in operable condition and frequently tested to ensure that the plant is always in a high condition of readiness.

We are, however, a learning organization and we continue to take advantage of the best-available information that we have to refine and improve our system. And one of the most significant changes that we made, after Three Mile Island in 1979, was an expansion of our resident inspector program, which now has at least two full-time NRC inspectors at each site where we have the ability to have unfettered access to the site at any time.

We have also developed guidelines for severe accident management to ensure that in the event, all of the things that we think are possible to happen, if the event—if something like—if something additionally were to happen, we have these severe accident management guidelines in place to ensure that we can deal promptly and in a systematic and methodical way with the unique safety challenges that may be presented.

In addition, as a result of the events of September 11, we identified important pieces of equipment that we require licensees to have available and in place, as well as new procedures and policies to help deal with the very severe type of situation that you are seeing in Japan right now. And our program of continuous improvement will also include lessons learned from the events in Japan.

We have already begun enhancing inspection activities through temporary instructions to our inspection staff, including the resident inspectors and the inspectors in all of our four regional offices. We have also issued an information notice to licensees to make them aware of activities they should undertake to verify that their capabilities to mitigate conditions due to these severe types of accidents, including the loss of significant operational and safety systems, are in effect and operation.

Now, although we are confident about the safety of United States nuclear power plants, our agency has a responsibility to the American people to undertake a systematic and methodical review in light of the events in Japan. On March 21, the NRC established a senior level task force to conduct a comprehensive review of our processes and regulations to determine whether improvements to our regulatory system are needed and to make recommendations to the NRC for its policy direction. This will—the review will basically encompass two pieces, there will be a short and then ultimately a longer-term review that will incorporate the best-available information that we have from Japan. And both of these reports will ultimately be made available to the public.

So in summary, I believe we have a strong regulatory program in place that looks at a wide variety of severe physical and natural phenomenon. In addition to that, we have a program in place to account for the things that we may not know today. And ultimately we have required all our plants to have equipment and procedures in place to deal with these very severe types of accident scenarios, in the very unlikely event that we were to see something like this develop here in the United States.

PREPARED STATEMENT

So I thank you for the opportunity to appear before you and I would be happy to answer any questions you may have. Thank you.

[The statement follows:]

PREPARED STATEMENT OF GREGORY B. JACZKO

Chairman Feinstein, Ranking Member Alexander, and members of the subcommittee, I appreciate the opportunity to appear before you to address the response of the United States Nuclear Regulatory Commission (NRC) to the recent tragic events in Japan. People across the country and around the world who have been touched by the magnitude and scale of this disaster are closely following the events in Japan and the repercussions in this country and in other countries.

I traveled to Japan over the past weekend, and just returned yesterday. I wanted to convey a message of support and cooperation to our Japanese counterparts there and to assess the current situation. I also met with senior Japanese Government and TEPCO officials, and consulted with our NRC team of experts who are in Japan as part of our assistance effort.

I would first like to reiterate my condolences to all those who have been affected by the earthquake and tsunami in Japan. Our hearts go out to all who have been dealing with the aftermath of these natural disasters, and we are mindful of the long and difficult road they will face in recovering. We know that the people of Japan are resilient and strong, and we have every confidence that they will come through this horrific time and move forward, with resolve, to rebuild their vibrant country. Our agency stands together with the people of Japan at this most difficult and challenging time.

The NRC is an independent agency, with approximately 4,000 staff. We play a critically important role in protecting the American people and the environment. Our agency sets the rules by which commercial nuclear power plants operate, and nuclear materials are used in thousands of academic, medical, and industrial settings in the United States. We have at least two resident inspectors who work full-time at every nuclear plant in the country, and we are proud to have world-class scientists, engineers, and professionals representing nearly every discipline.

Since Friday, March 11, when the earthquake and tsunami struck, the NRC's headquarters 24-hour emergency operations center has been fully activated, with staffing augmented to monitor and analyze events at nuclear power plants in Japan. At the request of the Japanese Government, and through the United States Agency for International Development, the NRC sent a team of its technical experts to provide on-the-ground support, and we have been in continual contact with them. Within the United States, the NRC has been working closely with other Federal agencies as part of our Government's response to the situation.

During these past several weeks, our staff has remained focused on our essential safety and security mission. I want to recognize their tireless efforts and their critical contributions to the United States response to assist Japan. In spite of the evolving situation, the long hours, and the intensity of efforts over the past week, NRC staff has approached their responsibilities with dedication, determination and professionalism, and I am incredibly proud of their efforts. The American people also can be proud of the commitment and dedication within the Federal workforce, which is exemplified by our staff every day.

The NRC's primary responsibility is to ensure the adequate protection of the public health and safety of the American people. Toward that end, we have been very closely monitoring the activities in Japan and reviewing all currently available information. Review of this information, combined with our ongoing inspection and licensing oversight, gives us confidence that the U.S. plants continue to operate safely. To date, there has been no reduction in the licensing or oversight function of the NRC as it relates to any of the U.S. licensees.

Our agency has a long history of conservative regulatory decisionmaking. We have been intelligently using risk insights to help inform our regulatory process, and, for more than 35 years of civilian nuclear power in this country, we have never stopped requiring improvements to plant designs, and modifying our regulatory framework as we learn from operating experience.

Despite the very high level of support being provided by the NRC in response to the events in Japan, we continue to remain focused on our domestic responsibilities.

I'd like to begin with a brief overview of our immediate and continuing response to the events in Japan. I then want to further discuss the reasons for our continuing confidence in the safety of the U.S. commercial nuclear reactor fleet, and the path forward for the NRC in order to learn all the lessons we can, in light of these events.

On Friday, March 11, an earthquake hit Japan, resulting in the shutdown of more than 10 reactors. The ensuing tsunami appears to have caused the loss of normal and emergency alternating current power to the six unit Fukushima Daiichi site. It is those six units that have received the majority of our attention since that time. Units 1, 2, and 3 were in operation at the time of the earthquake. Units 4, 5, and 6 were in previously scheduled outages.

Shortly after 4 a.m. EDT on Friday, March 11, the NRC Emergency Operations Center made the first call, informing NRC management of the earthquake and the potential impact on U.S. plants. We went into the monitoring mode at our Emergency Operations Center, and the NRC's first concern was possible impacts of the tsunami on U.S. plants and radioactive materials on the West Coast, and in Hawaii, Alaska, and U.S. territories in the Pacific. We were in communication with licensees and NRC resident inspectors at Diablo Canyon Power Plant and San Onofre Nuclear Generating Station in California, and the radiation control program directors for California, Washington, Oregon, and Hawaii.

On that same day, we began interactions with our Japanese regulatory counterparts and dispatched two experts to Japan to help at the United States Embassy in Tokyo. By Monday, March 14, we had dispatched a total of 11 NRC staff to provide technical support to the American Embassy and the Japanese Government. We have subsequently rotated in additional staff to continue our on-the-ground assistance in Japan. The areas of focus for this team are:

—to assist the Japanese Government and respond to requests from our Japanese regulatory counterparts; and

—to support the U.S. Ambassador and the U.S. Government assistance effort.

On Wednesday, March 16, we collaborated with other U.S. Government agencies and decided to advise American citizens to evacuate within a 50-mile range around the plant. This decision was a prudent course of action and would be consistent with what we would do under similar circumstances in the United States. This evacuation range was predicated on a combination of the information that we had available at the time, which indicated the possibility that reactor cores and spent-fuel pools may have been compromised, and hypothetical calculations of the approximate activity available for release from one reactor and two spent-fuel pools at a four-reactor site.

We have an extensive range of stakeholders with whom we have ongoing interaction regarding the Japan situation, including the White House, congressional staff, our State regulatory counterparts, a number of other Federal agencies, and international regulatory bodies around the world.

The NRC response in Japan and our emergency operations center continue with the dedicated efforts of more than 250 NRC staff on a rotating basis. The entire agency is coordinating and working together in response to this event so that we can provide assistance to Japan while continuing the vital activities necessary to fulfill our domestic responsibilities.

It is important to note that the U.S. Government has an extensive network of radiation monitors across this country. Monitoring at nuclear power plants and the U.S. Environmental Protection Agency's system has not identified any radiation levels that effect public health and safety in this country. In fact, natural background radiation from sources such as rocks, the Sun, and buildings, is 100,000 times more than doses attributed to any level that has been detected in the United States to date. Therefore, based on current data, we feel confident that there is no reason for concern in the United States regarding radioactive releases from Japan.

There are many factors that assure us of ongoing domestic reactor safety. We have, since the beginning of the regulatory program in the United States, used a philosophy of "Defense-in-Depth", which recognizes that nuclear reactors require the highest standards of design, construction, oversight, and operation, and does not rely on any single layer of protection for public health and safety. Designs for every individual reactor in this country take into account site-specific factors and include a detailed evaluation for natural events, such as earthquakes, tornadoes, hurricanes, floods, and tsunamis, as they relate to that site.

There are multiple physical barriers to radiation in every reactor design. Additionally, there are both diverse and redundant safety systems that are required to be maintained in operable condition and frequently tested to ensure that the plant is in a high condition of readiness to respond to any situation.

We have taken advantage of the lessons learned from previous operating experience to implement a program of continuous improvement for the U.S. reactor fleet. We have learned from experience across a wide range of situations, including most significantly, the Three Mile Island accident in 1979. As a result of those lessons learned, we have significantly revised emergency planning requirements and emergency operating procedures. We have addressed many human factors issues regarding how control room employees operate the plant, added new requirements for hydrogen control to help prevent explosions inside of containment, and created requirements for enhanced control room displays of the status of pumps and valves.

The NRC has a post-accident sampling system that enables the monitoring of radioactive material release and possible fuel degradation. One of the most significant changes after Three Mile Island was an expansion of the Resident Inspector Program, which now has at least two full-time NRC inspectors onsite at each nuclear power plant. These inspectors have unfettered access to all licensees' activities related to nuclear safety and security.

As a result of operating experience and ongoing research programs, we have developed requirements for severe accident management guidelines. These are components and procedures developed to ensure that, in the event all of the above-described precautions failed and a severe accident occurred, the plant would still protect public health and safety. The requirements for severe accident management have been in effect for many years and are frequently evaluated by the NRC inspection program.

As a result of the events of September 11, 2001, we identified important pieces of equipment that, regardless of the cause of a significant fire or explosion at a plant, the NRC requires licensees to have available and staged in advance, as well as new procedures and policies to help deal with a severe situation.

Our program of continuous improvement, based on operating experience, will now include evaluation of the significant events in Japan and what we can learn from them. We already have begun enhancing inspection activities through temporary instructions to our inspection staff, including the resident inspectors and the region-based inspectors in our four regional offices, to look at licensees' readiness to deal with both design-basis accidents and beyond-design-basis accidents.

We have also issued an information notice to licensees to make them aware of the events in Japan, and the kinds of activities we believe they should be engaged in to verify their readiness. It is expected that licensees review the information related to their capabilities to mitigate conditions that result from severe accidents, including the loss of significant operational and safety systems, to ensure that they are in effect and operational.

During the past 20 years, there have been a number of new rulemakings that have enhanced the domestic fleet's preparedness against some of the problems we are seeing in Japan. The "station blackout" rule requires every plant in this country to analyze what the plant response would be if it were to lose all alternating current so that it could respond using batteries for a period of time, and then have procedures in place to restore alternating current to the site and provide cooling to the core.

The hydrogen rule requires modifications to reduce the impacts of hydrogen generated for beyond-design-basis events and core damage. There are equipment qualification rules that require equipment, including pumps and valves, to remain operable under the kinds of environmental temperature and radiation conditions that you would see under a design-basis accident.

With regard to the type of containment design used by the most heavily damaged plants in Japan, the NRC has had a Boiling Water Reactor Mark I Containment Improvement Program since the late 1980s. This program required installation of hardened vent systems for containment pressure relief, as well as enhanced reliability of the automatic depressurization system.

A final factor that underpins our belief in the ongoing safety of the U.S. fleet is the emergency preparedness and planning requirements in place that provide ongoing training, testing, and evaluations of licensees' emergency preparedness programs. In coordination with our Federal partner, the Federal Emergency Management Administration, these activities include extensive interaction with State and local governments, as those programs are evaluated and tested on a periodic basis.

Along with our confidence in the safety of United States nuclear power plants, our agency has a responsibility to the American people to undertake a systematic and methodical review of the safety of our domestic facilities, in light of the natural disaster and the resulting nuclear situation in Japan.

Examining all available information is an essential part of the effort to analyze the event and understand its impact on Japan and its implications for the United States. Our focus is always on keeping nuclear plants and radioactive materials in this country safe and secure.

On Monday, March 21, my colleagues at the NRC and I met to review the status of the situation in Japan and identify the steps needed to conduct that review. We consequently decided to establish a senior level agency task force to conduct a comprehensive review of our processes and regulations to determine whether the agency should make additional improvements to our regulatory system, and to make recommendations to the NRC for its policy direction.

The review will be conducted in both a short-term and a longer-term timeframe. The short-term review has already begun, and the task force will brief the NRC at 30-, 60-, and 90-day intervals, to identify potential or preliminary near-term operational or regulatory issues. The task force then will undertake a longer-term review as soon as NRC has sufficient information from the events in Japan. That longer-term review will be completed in 6 months from the beginning of the evaluation.

The task force will evaluate all technical and policy issues related to the event to identify additional potential research, generic issues, changes to the reactor oversight process, rulemakings, and adjustments to the regulatory framework that may warrant action by the NRC. We also expect to evaluate potential interagency issues, such as emergency preparedness, and examine the applicability of any lessons learned to nonoperating reactors and materials licensees. We expect to seek input from all key stakeholders during this process. A report with appropriate recommendations will be provided to the NRC within 6 months of the start of this evaluation. Both the 90-day and final reports will be made publicly available.

In conclusion, I want to reiterate that we continue to make our domestic responsibilities for licensing and oversight of the U.S. licensees our top priority and that the U.S. plants continue to operate safely. In light of the events in Japan, there will be a near-term evaluation of their relevance to the United States fleet, and we are continuing to gather the information necessary to take a longer, more comprehensive and thorough look at the events in Japan and their lessons for us. Based on these efforts, we will take all appropriate actions necessary to ensure the continuing safety of the American people.

Chairman Feinstein, Ranking Member Alexander, and members of the subcommittee, on behalf of the NRC, thank you for the opportunity to appear before you. I look forward to continuing to work with you to advance the NRC's important safety mission.

Senator FEINSTEIN. Thanks very much, Mr. Chairman.

Secretary Lyons.

STATEMENT OF DR. PETER B. LYONS, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY

Mr. LYONS. Thank you. Chairman Feinstein, Ranking Member Alexander and Senator Lautenberg, thank you for the opportunity to appear before you today to discuss the nuclear accident situation in Japan, the DOE's response and our research, development and deployment programs relevant to nuclear safety.

I will leave discussion of the accident itself to my written testimony and focus now on the DOE's response and our ongoing RD&D programs.

To assist in the country's response, the National Nuclear Security Administration's (NNSA) Nuclear Incident Team Operations Center was promptly activated and has been continuously staffed by both the NNSA and Office of Nuclear Energy personnel since the accident. The focus of all DOE activities has been to understand the accident progression and offer advice and assistance to

Japanese officials who have the direct responsibility to manage the accident recovery.

The DOE has deployed about 40 people and more than 1,700 pounds of equipment, including NNSA's aerial measuring system (AMS), and a number of consequent management response teams. The AMS measures radiological contamination on the ground deposited from transit of any released plumes. The AMS data, taken now over a number of days, are consistent with reduced levels of radiation compared to earlier measurements and show no evidence of significant new releases, between March 19 and March 29. In addition, NNSA has been modeling potential transport of radioactive materials released from the plant, utilizing the national atmospheric release advisory capability at the Lawrence Livermore National Laboratory.

As Chairman Jaczko has also stated, we do not believe that the radiation released by the plant poses a public health danger in the United States, although certainly low levels, trace levels of radioactivity attributable to the accident have been observed here. The Office of Nuclear Energy has established a nuclear energy response team to utilize the capabilities of the DOE national laboratories in a wide range of analyses. We are also working at the United States Embassy in Tokyo, with NRC staff in Japan and in Rockville, Maryland and with Japanese agencies and industry.

DOE and the NRC worked directly with the Institute for Nuclear Power Operations (INPO), and the Nuclear Energy Institute to encourage formation of an industry-led assistance team. INPO is now leading this industry team deployed both in Japan and at INPO headquarters in Atlanta. And in addition, Secretary Chu and White House Science and Technology Advisor John Holdren have reached out to laboratory directors and other eminent scientists for technical advice. They are in touch with them on a daily basis, as well as with an internal team of scientists and engineers to analyze the situation, suggest new approaches and evaluate potential solutions.

Now beyond our response to the accident, the research development and deployment programs of my office are highly relevant to future decisions about potential options for nuclear power in the United States. Our proposed SMR program will explore designs that offer safety advantages through extensive use of passive systems. We are also conducting research and development into high-temperature, gas-reactor designs that offer inherent design safety features. Our light water reactor (LWR) sustainability program is exploring whether the lifetime of operating reactors can be extended with no compromise in safety. Researching fuel cycles is also within my office.

While we await guidance from the Blue Ribbon Commission on America's nuclear future, we are conducting research and development into a broad range of options for the Nation's fuel cycle, with careful attention to safety, environmental protection, and nonproliferation.

Safety of future systems is really the key to all of our programs. Selected research areas like fuel claddings that cannot generate hydrogen in an accident or fuels that are virtually impossible to melt have very obvious relevance. And the new modeling and simulation hub which is based at Oak Ridge National Laboratory will provide important new capabilities to the nuclear industry, capabilities that can be used to assess and improve the safety of existing reactors.

Deputy Secretary Dan Poneman recently stated that we view nuclear energy as a very important compliment to the overall portfolio we are trying to build for a clean energy future. The programs of the Office of Nuclear Energy are focused on assuring that the option for safe nuclear power remains open to the Nation.

PREPARED STATEMENT

In conclusion, the earthquake and the resulting tsunami brought tremendous devastation on Japan. At the DOE we are making every effort to assist the Japanese people in their time of need.

Thank you and I look forward to your questions.

[The statement follows:]

PREPARED STATEMENT OF DR. PETER B. LYONS

Chairman Feinstein, Ranking Member Alexander, and members of the subcommittee, thank you for the opportunity to appear before you today to discuss the nuclear accident situation in Japan and the Department of Energy's (DOE) response.

Let me briefly recap our current understanding of events at the Fukushima-Daiichi nuclear power plant with its six nuclear reactors, albeit with many gaps in our knowledge. When the earthquake on March 11 struck, the three operating reactors (Units 1, 2, and 3) shut down in accordance with operating procedures. Backup diesel generators started per procedures to keep the water pumps and instrumentation operational. But when the earthquake-generated tsunami struck, those backup power generators were damaged.

Units 1, 2, and 3 used battery power to continue to run their cooling pumps until the batteries were drained or the pumps failed. As the reactor cores heated from radioactive decay, steam was produced. The pressure buildup from that steam required venting, which released some radioactive materials. It also lowered the water level in the three reactor pressure vessels, reducing the cooling of the core. It appears that all three reactor cores are damaged to unknown extents. Additionally, as the fuel rod temperature increased, a reaction took place between the zirconium fuel cladding and the water in the pressure vessel, producing hydrogen. This hydrogen was vented along with the steam and may have ignited at all three reactors. Substantial explosive damage is visible at Units 1 and 3, presumably from these explosions. An explosion may have damaged the containment structure at Unit 2. Fission products have been released through these processes. Once pumper units were brought in, seawater cooling was used for many days until fresh water supplies were available.

Water levels at the spent-fuel pools are also of concern with some reports that at least one was empty for some time. Depending on the condition of the pools and the age of the fuel in the pool, the cladding of the used fuel could ignite. Such a zirconium fire would be very difficult to extinguish and could potentially lead to significant releases. Seawater was also used to cool spent-fuel pools, until fresh water supplies were obtained.

Current information suggests that the plants are in a slow recovery from the accident. Long-term cooling of the reactors and pools is essential during this period. A massive cleanup operation remains for the future.

To assist in the United States' response, National Nuclear Security Administration's (NNSA) Nuclear Incident Team (NIT) Operations Center was promptly activated and has been continuously staffed by NNSA and Office of Nuclear Energy personnel since the accident. The focus of all DOE activities, led by the operations center, has been to understand the accident progression and offer advice and assistance to the Japanese officials who have the direct responsibility to manage the accident recovery.

The DOE has deployed about 40 people and more than 17,000 pounds of equipment to Japan, including NNSA's Aerial Measuring System (AMS) and Consequence Management Response Teams. The response teams on the ground are utilizing their unique skills, expertise, and equipment to help assess, survey, monitor, and sample ground areas for radiation. Since arriving in Japan, the AMS team has collected and analyzed data gathered from more than 40 hours of flights aboard Department of Defense fixed wing and helicopter platforms. Sampling of airborne radiological material, coupled with spectroscopic measurements by the DOE team, have helped to determine that virtually all the material studied to date is consistent with releases from operating reactors, not the used fuel in the pools from which short-lived radioactive materials have already decayed.

The AMS measures radiological contamination on the ground deposited from transit of any release plumes. We are sharing the results of these measurements with Japanese officials. In addition, AMS data are available on the DOE Web site.

As of March 19, 2011, all AMS measurements beyond 2.5 miles from the reactor were below 30 millirem per hour. Elevated readings have been observed within about 25 miles of the Fukushima-Daiichi Nuclear Power Plant and a distinctive pattern to the ground deposition is readily observable with an area of higher contamination extending to the northwest of the plant. The AMS was grounded by weather for several days and flew again on March 24. The new data are consistent with reduced levels of radiation compared to the earlier measurements and show no evidence of significant new releases between March 19 and 24.

In addition, the NNSA has been performing in-country and long-distance modeling of potential plume movement using the National Atmospheric Release Advisory Capability (NARAC) at Lawrence Livermore National Laboratory. The NRC supplies the hypothetical source terms for these NARAC calculations.

The Office of Nuclear Energy has established a Nuclear Energy Response Team (NERT). The purpose of this team is threefold:

—Provide expert analysis on reactor conditions to DOE leadership from reported information and investigate discrepancies or conflicting reports.

—Support the NIT Operations Center with analysis or additional information as needed.

—Coordinate analysis activities at the DOE national laboratories in support of the above.

The NERT consists of eight sub-teams organized by major systems of the reactor (e.g., cooling, electrical power, reactor vessel) that meets twice daily.

The Office of Nuclear Energy has staff in Japan working directly with NRC's staff in Japan and with the Japanese agencies and industry. We also have a representative at the NRC operations center in Rockville. The Office of Nuclear Energy is also in contact with the GE-Hitachi command centers.

DOE and NRC have worked with the Institute for Nuclear Power Operations (INPO) and the Nuclear Energy Institute (NEI) to encourage formation of an industry assistance team. INPO is now leading this industry team, deployed both in Japan and at INPO headquarters in Atlanta. Members of the NERT are in regular contact with the INPO teams.

In addition, Secretary Chu and White House Science and Technology Advisor John Holdren have jointly set up an informal group of experts on reactor safety and accident mitigation from inside and outside the Government. The group has a daily teleconference in which the newest information is discussed and the individual members convey their thoughts about the most promising approaches to the Secretary and Dr. Holdren.

Beyond our response to the accident, the research, development, and deployment programs of the Office of Nuclear Energy are highly relevant to future decisions about the potential options for nuclear power in the United States. Our proposed Small Modular Reactor program will explore designs that offer safety advantages through extensive use of passive systems. We are also conducting research and development into high-temperature, gas-reactor designs that offer inherent safety features. The Light Water Reactor Sustainability Program is exploring whether the lifetime of operating reactors can be extended with no compromise in safety.

The Office of Nuclear Energy also performs research on fuel cycles. We are conducting R&D into a broad range of options for the Nation's fuel cycle with careful attention to safety, environmental protection, and nonproliferation. In addition, our cross-cutting research into areas like advanced materials and instrumentation is exploring technologies that could enable future safety enhancements, like fuel claddings that cannot generate hydrogen in an accident or fuels that are virtually impossible to melt. And the new Modeling and Simulation Hub, based at the Oak Ridge National Laboratory, will provide new capabilities to the nuclear industry, capabilities that can be used to assess and improve the safety of existing reactors.

I fully concur with the statement made by Deputy Secretary Poneman at a White House briefing on March 14 that: "We view nuclear energy as a very important component to the overall portfolio we are trying to build for a clean energy future." The programs of the Office of Nuclear Energy are focused on assuring that the option for safe nuclear power remains open to the Nation.

In conclusion, the earthquake and resulting tsunami have visited tremendous devastation on Japan. Those of us at the DOE are making every effort to assist the Japanese people in their time of need.

Senator FEINSTEIN. Thank you very much. And we will proceed to the questions.

Mr. Chairman, I would like to begin with you. The ranking member mentioned there are 104 operating nuclear power reactors at 65 sites in our country. I understand there are 48 dry cask storage facilities in the United States. If my numbers are accurate, does this mean that there are 17 reactor sites with no dry cask storage option?

Mr. JACZKO. If your numbers are correct there are some sites that have not yet gone to dry cask storage. We anticipate, in time, that most sites will eventually move in that direction.

Senator FEINSTEIN. So the fuel rods just remain in the spent-fuel pools?

Mr. JACZKO. Correct. And for those sites that have not gone to dry cask storage, they remain in the pools. And these pools are very robust structures that are designed to deal with the kinds of natural phenomenon that we designed the entire reactor site to. It is very thick, reinforced concrete structures, generally about 4- to 5-feet thick walls with very thick floors, so they provide, we think, a very robust protection for the fuel.

Senator FEINSTEIN. Let me ask this. What are the regulatory requirements relative to spent fuel? They can just sit forever in spent-fuel pools?

Mr. JACZKO. The way our requirements are based is we have requirements about the minimum amount of time that the fuel would need to be in the pool. So generally we think about 5 years or so is a reasonable timeframe for the fuel to need to be in the pool, simply because it is very physically hot, so it—that heat needs to dissipate and that needs to happen in the pool itself.

Senator FEINSTEIN. Do you have a maximum time?

Mr. JACZKO. We don't have a maximum time, but we do analyze the fuel that is in the pool. And if, as new fuel were to be added to the pool, that goes through a very rigorous analysis to ensure that that can be done safely and securely.

Senator FEINSTEIN. So one wouldn't be surprised, in these plants, to see fuel in those spent-fuel pools for decades?

Mr. JACZKO. That is possible, certainly. Many sites have begun to move, as you indicated, their fuel out of the pools into dry cask storage. Generally, what the utilities like to do is reserve some amount of space in the pool to be able to take the fuel that is in the reactor at any time and move that into a pool. So that tends to be the condition at which if they lose that ability to have that extra space, then they will usually move to dry cask storage to store the fuel.

Senator FEINSTEIN. Well, in the two plants I looked at, with respect to the dry casks, the casks at one plant were standing outside and the casks at the other plant were in a water-resistant building. Are there any standards for dry cask storage?

Mr. JACZKO. We—the dry cask storage systems are required to be certified by the NRC to, again, meet very rigorous standards for dealing with natural phenomenon and as well as ensuring the safety of the fuel itself. So there are basically two types of systems that are generally used, and I think you saw examples of those two types at Diablo Canyon and San Onofre. So we have approved those and again, they meet our high standards for natural phenomenon, for ensuring that the fuel will stay sufficiently cool and that we won't have any type of nuclear reaction in the fuel itself.

Senator FEINSTEIN. Why aren't there better standards for spent-fuel pools? You have good standards for the reactor, but, it seems to me, not for the spent fuel.

Mr. JACZKO. Well, the spent-fuel pools are considered safety significant systems. So they meet a lot of the same standards that the reactor itself would have to meet. For instance, the spent-fuel pools themselves are required to withstand the natural phenomenon like earthquakes and tsunamis that could impact the reactor itself. They are required—the spent fuel is required to be able to deal with these severe accidents. It is also required to be able to deal with the possibility of any type of nuclear reaction happening in the pool itself. So there are very high standards and they're very comparable to the reactors themselves.

Senator FEINSTEIN. Well, didn't Japan have similar standards? Yet, the spent-fuel pools could not withstand the tsunami and the earthquake.

Mr. JACZKO. At this point we don't know exactly what contributed to the situation with the spent-fuel pools in Japan. It's unclear whether that was a direct result of the earthquake itself or whether there was subsequent actions, such as the hydrogen explosions that occurred, that created a more difficult situation with the spent-fuel pools. But, I would add, from what we do know right now, there are six spent-fuel pools in Japan and we believe with a good level of confidence that certainly the spent-fuel pool for unit one has operated normally without any particular challenge, the unit pool—the unit two pool as well has operated fine. The challenges we're seeing are really with units 3 and 4. But units 5 and 6 also were operating in a stable way at this time. So we haven't seen challenges with all the pools in Japan, just a small subset.

Senator FEINSTEIN. Was it cracks in the superstructure of the pool itself that caused the two to fail?

Mr. JACZKO. Right now we don't know for sure what the situation is. We believe it is possible that there was perhaps a leak in the unit 3 pool and that perhaps there were some other challenges with the unit 4 pool. But again, we don't know at this point whether that was the result of the earthquake and the tsunami or some of the subsequent events that happened. So those are the kinds of things we will be looking at as we embark on our short term and our longer term to analyze that.

Senator FEINSTEIN. Thank you very much.

Senator Alexander.

Senator ALEXANDER. Thank you, Madam Chair. Mr. Jaczko, continuing the chairman's comments, most of the problems we read and hear about in Japan from the reactors comes basically from the inability to cool some of the used fuel rods. Is that right?

Mr. JACZKO. Well, I think it is—there are really two issues that we are looking at. One is ensuring the continued cooling of the reactors themselves and then maintaining the cooling in the pool, so both of those issues are important.

Senator LAUTENBERG. Cooling—it is a cooling issue?

Mr. JACZKO. It is a cooling issue for us.

Senator ALEXANDER. When we talk about storing all the spent nuclear fuel in the United States produced in the last 35 years, by my mathematics, roughly speaking, it would fit on a single football field 20 feet deep. Is that right?

Mr. JACZKO. I believe I have seen estimates like that. I think that is approximately correct.

Senator ALEXANDER. And today that spent nuclear fuel is stored on the site where the nuclear reactor is, according to your rules and regulations. How long can that be safely stored there?

Mr. JACZKO. Well, right now the NRC recently affirmed a decision we have made over the years that we call our waste confidence decision. And in that decision we look at what the long-term impacts, ultimately the long-term environmental impacts are from that spent fuel. And right now we believe that for at least a hundred years that fuel can be stored with very little impacts to health and safety or to the environment.

In addition, as part of that decision the NRC asked the staff at the agency to go out and take a look to really see if you are to go out 2 or 3 or 400 years if there are any safety issues that could arise that would present a challenge to the kind of approach we have right now for dealing with spent fuel.

So right now we believe that this is material that can be stored safely and securely in either the spent-fuel pools themselves or in dry cask storage.

Senator ALEXANDER. So what you are saying is that most of the reactor problems we have been reading about in Japan have to do with the cooling of used nuclear fuel or spent fuel, and that in the United States, the amount of material we have produced over the last 35 years which is currently stored in pools or dry casks at various sites, would only fill a football field 20-feet deep.

Mr. JACZKO. Sixty-five sites.

Senator ALEXANDER. And it is your estimate or the NRC's estimate that it can be safely stored there for up to 100 years?

Mr. JACZKO. That is our assessment right now. Yes.

Senator ALEXANDER. Now, I want to compliment the President. When he started his administration I was afraid he was going to lead us on a national windmill policy instead of a national energy policy. But his attitude toward nuclear power, in my opinion, has been thoughtful and balanced, including through this crisis. He has appointed excellent people to your NRC. Dr. Chu has been a strong appointment. He has recommended loan guarantees for the first new nuclear plants and more important, or equally important, he has a distinguished panel looking at the future of used nuclear fuel.

And I want to ask you to comment on that, you or Mr. Lyons.

As I understand it, while we can safely store used nuclear fuel onsite for 100 years, what the President and others are suggesting is that we research a better way to store it. That might include reducing its volume by 70, 80, or 90 percent, making it that much smaller, finding ways that plutonium isn't separated from it, recycling it or using it over and over again. So the bottom line is that we are comfortable with being able to store it in its current form and location for up to 100 years, but over the next 10 to 20 years we will be looking for a better way to recycle and reuse it, and that is what we're hoping to find from the recommendations of the President's commission.

Am I approximately right in that or what comments would you add?

Mr. JACZKO. Well, I would defer to Secretary Lyons probably—he can best answer that question, I think.

Mr. LYONS. Well, Senator Alexander, as you note, the mission of the Blue Ribbon Commission is to explore a wide range of options for management of used fuel, the back end of the fuel cycle. And certainly at the DOE we are eagerly awaiting their reports and their suggestions and guidance. The interim report of that group is due by July 29, final report by January of next year. And we anticipate that that will provide important guidance to the range of R&D programs that we have at the DOE.

Now while we are awaiting that report, we do maintain a broad spectrum of research ranging from the once through cycle that the country has now and understanding how that could be improved or sustained, all the way to different options including the reprocessing that you're describing. And we view our goal as providing a set of options to the American people, certainly guided by the output of the Blue Ribbon Commission that can lead to a long-term sustainable policy for used fuel management in the country.

Senator ALEXANDER. Thank you, Madam Chair.

Senator FEINSTEIN. Thank you very much, Senator.

Senator Lautenberg.

Senator LAUTENBERG. Yes. Thank you, Madam Chairman. Thank you both for your excellent testimony.

Dr. Jaczko, do we have a better regulatory system than Japan? Is there a difference in the two systems?

Mr. JACZKO. Well, I think every country that has nuclear power takes a different approach to dealing with the safety of the reactors in their country. I think we have a system that is well-suited to dealing with the safety of the reactors in this country. It is a system, as I said, that relies on multiple layers of protection and it incorporates a strong basis in technical information. And we have a very strong presence of inspectors at the reactor sites. So we think that this provides a very strong system to ensure the safety of plants in the United States.

Senator LAUTENBERG. We, in our conversation yesterday we discussed a total review of all plants in America and I think that your time target was 90 days. Is that correct?

Mr. JACZKO. We are looking at a short-term review in 90 days and that will be followed by a much longer-term review as we get more detailed information from Japan.

Senator LAUTENBERG. So we can be assured that the problems that we saw in Japan will have a review of possibility here in our—with our plants here in the country?

Mr. JACZKO. Absolutely. That is the focus of these reviews.

Senator LAUTENBERG. Well, the—you know, we have the oldest plant, commercial plant in America, built in 1969. The Fukiama plants I think were built in 1971. Is that—am I correct?

Mr. JACZKO. Yes.

Senator LAUTENBERG. Is there any question about age of facility that might have—that contributed to the difficulty there?

Mr. JACZKO. At this point we don't know what the exact causes of the situation in Japan are. But again, if we look at the situation for the U.S. reactors, all the reactors that we have that are of a similar type have undergone modifications and improvements to deal with the kinds of situations that we are seeing in Japan.

For instance, it has been known, since the late 1980s and early 1990s that the accumulation of hydrogen presents a significant challenge. So the reactors of this type in particular were modified to ensure that they could better mitigate or reduce the likelihood of that type of hydrogen explosion. So we think we have a program, or we have a program that addresses these issues, but we will do these comprehensive reviews to ensure that there isn't any information that we have missed and that can better enhance the safety.

Senator LAUTENBERG. Mr. Jaczko, can we say, without fear of contradiction that our plants in New Jersey are updated, able to deal with any malfunction of the operation there? Because in April 2009, I am sure you recollect—April 2009, August 2009—we had low level tritium leaks. Now tritium is a fairly dangerous material and what assurance can I give the people in the surrounding area that: we did or did not find any health consequences of the tritium leaks; were there examinations called for in the area and did we find anything that—within the—those families that there—they have to be concerned about?

Mr. JACZKO. Well, with regard to the tritium leaks we believe that that is not an acceptable situation for any power reactor in the United States to have that kind of a leak. With regard to the Oyster Creek leak, we did not see any indication of any risk to public health and safety as a result of those particular leaks. And in fact, the facility has made significant modifications to dramatically reduce the likelihood of something like that happening in the future.

And I would add that those leaks were not in systems that directly affect the ability of the reactor to deal with accidents and errors or to ensure that the reactor itself or the spent-fuel pools continue to function safely and securely.

Senator LAUTENBERG. Thank you, Madam Chairman and thank you again witnesses.

Senator FEINSTEIN. Thank you, Senator.

Senator LAUTENBERG. I assume the record will remain open?

Senator FEINSTEIN. It will remain open.

Senator LAUTENBERG. Thank you.

Senator FEINSTEIN. Senator Durbin.

Senator DURBIN. Thanks a lot. And it is an honor to be part of our subcommittee. Thank you, Madam Chair and Senator Alexander.

And so, if my memory serves me, it was—Three Mile Island was 1979? Is that correct?

Mr. JACZKO. Correct.

Senator DURBIN. And I would say, for 32 years the nuclear power industry has really been stymied, frozen in place with virtually no major expansion across the United States in the heels—on the heels of that controversy.

And I am wondering now if the same thing is going to happen as a result of Japan. Whether there will be serious questions raised about operations and about design and about nuclear waste that will once again cause this industry to stop, reflect and probably slow down any plans to advance.

I also understand the economics of energies. I have been told that natural gas electric power creation is a much cheaper alternative and obviously safer in many respects. So that seems to be the general view of the out—what I see coming as an outgrowth of the Japanese tragedy.

We had a hearing last week in Illinois, because we are so nuclear power dependent, one-half of our electricity is generated by the nuclear power, we have 11 generators and 4 of them are exactly the same design as Fukushima. And representatives of your agency came, as did State and local and private sector and we had a long conversation about many things, including the nuclear waste onsite, spent nuclear fuel rods onsite in Illinois, 7,200 tons worth of those nuclear—pardon me, spent nuclear fuel rods.

We talked about many different things and we talked about Yucca Mountain. And I recall from my college, the "Myth of Sisyphus" pushing that boulder up the hill and barely getting to the top and it rolls back to the bottom. And now we realize that the name of that hill is Yucca Mountain. It appears that we keep rolling this boulder up close to the top and never quite reach it.

And I don't know ultimately whether this, I think it is $90 billion current estimate of investment in Yucca Mountain will ever take place, and if it does it is probably 10 years over the horizon when the decision is made. And I have to ask and bring up a question which came up at our hearing. What about the situation with reprocessing? There was a time when we took a national position on it to try and be an example to the world, not to reprocess and create an opportunity to use plutonium for the development of weapons. But I think what is happening or what I see today is that two of our major allies in the world, Britain and France, France in particular, have decided that reprocessing is not only okay, it is a great commercial investment and they are receiving the waste from other countries and reprocessing it, dramatically reducing the size of the remaining radioactive challenge.

Is that thinking from the Carter administration really appropriate today? Are we not in a world that has accepted reprocessing? Shouldn't we be looking at it ourselves as an alternative to a $90 billion Yucca Mountain investment that might come online 10 years from now?

Mr. JACZKO. Well I, Senator I will briefly answer from the NRC's perspective and Dr. Lyons probably can give you a better answer to that question. We are currently doing work to develop an infrastructure to support a reprocessing facility in this country. That activity is at a probably a medium-to-low-level priority in the agency, because of what we see from the commercial sector about interest in the immediate development or deployment of a reprocessing facility, but there certainly is discussion right now and perhaps Dr. Lyons can provide more information on that.

Senator DURBIN. Before you go any further, let me stop you. You said there is a lack of interest in the commercial sector? Wouldn't this be our Government responsibility?

Mr. JACZKO. It is certainly possible that it could be a Government responsibility, but it could also be a private sector development of a private reprocessing facility to do that.

Senator DURBIN. But is it your belief that the private sector in nuclear power believes that maintaining these pools across the United States is a viable alternative?

Mr. JACZKO. Well, certainly from the agency's perspective we think that that can be done safely and securely. The ultimate decisions about how to manage that spent fuel are really decisions for the Federal Government and the private sector itself about how long term they want to maintain that.

For instance, some utilities move more fuel more quickly into dry cask storage; others leave it in pools——

Senator DURBIN. If I remember the debate on this, the push for Yucca Mountain came from the private sector. And the argument was, "We don't want to be responsible any longer for the spent nuclear fuel rods and the danger associated with them. We want the Federal Government to accept the responsibility, we believe it is theirs, and build Yucca Mountain." So you are saying when it comes to reprocessing though, they are not interested in that development?

Mr. JACZKO. Well, I think there is some interest right now. I would say it is—as with any type of fuel, there is an industry that provides fuel for the reactors; there are economic considerations that go into whether or not reprocessing is the most effective way to provide that fuel. And I think in many ways that is what is driving the commercial side, in terms of their interest in reprocessing or no reprocessing. It is a cost issue in many ways right now.

Senator DURBIN. I am over time, but Dr. Lyons, if you would like to respond.

Mr. LYONS. Well, my response would be very lengthy. You asked many, many questions, sir and maybe I can come back to it in subsequent rounds. But, just to answer a few of your questions. You started with, "Will the incidents in Japan impact growth here on nuclear power?" Personally, I think that the review that the NRC will be conducting, the International Atomic Energy Agency (IAEA) has announced there will be international reviews where the international community will compare lessons learned, I think all of those factors will come together to help understand, and certainly for the NRC, to decide whether any regulatory changes are required that may impact the progression of nuclear power in the country.

You alluded to, and I certainly agree, that the very low price of natural gas, the absence of any value placed on carbon certainly tends to favor approaches to new power like natural gas. And I think that impacts any of the clean energy solutions.

I can launch into a discussion on reprocessing and I'd like to do that, but we are way over the time, so I will leave it up to you folks as to whether I should proceed.

Senator DURBIN. This is my first hearing in the subcommittee and I don't want to abuse the privilege.

Senator FEINSTEIN. Thank you very much, Senator. This has been very interesting. I want to thank you.

I do want to move on, but I just want to say something. Mr. Chairman, you said that spent fuel could be stored safely and securely for 100 years either in spent fuel pools or dry casks. I am amazed that storing it in these pools for that period of time, while these pools are being racked and reracked now, with more and more of them in the pools. You know when the design basis of these plants was put into effect a lot of the threats weren't present. You know, we didn't worry about a terrorist bomb at our nuclear power plants as we do today. You have got all these spent fuel rods, very hot against some of them that have cooled off somewhat.

I always thought that dry casks were the best kind of long-term storage. And to me 100 years is long-term storage.

Mr. JACZKO. Well, there is—I think this is very much an issue that the NRC is going to take a look at again, I think without a doubt, as part of this short-term and long-term review. But the information we have right now shows that both of these methodologies are equally safe for a very long period of time. What—obviously if you are getting to 60, 70 years of spent-fuel pool storage, that likely would not happen because that long period of time the reactor has likely been shut down and undergoing a period of decommissioning. And that would involve taking the fuel out of the pools and putting it in dry cask storage. So, in that longer-term scenario you would likely see most of the fuel being moved into dry cask at that point.

And as the fuel does get cooler the likelihood of the very severe type of accident from a spent fuel gets reduced significantly. The concern is that you have a fire essentially and it releases a lot of radioactive material from the spent-fuel pools. As the fuel ages, the likelihood of that fire reduces dramatically.

Senator FEINSTEIN. But you are adding new rods all the time.

Mr. JACZKO. As part of the process we have required the licensees, when they add new fuel that they add it in such a way that they balance the various—they distribute the hot fuel in such a way that it really reduces the likelihood of this type of fire. So you—they move and shuffle all of the fuel each time so that you always have hot fuel that is surrounded by much cooler fuel to reduce the likelihood of these kinds of challenges.

But again, as you really play out the much longer term, 60, 70, 80 years, we would envision that at that point most fuel begins to move out of the pools and into dry cask storage. It is—of course the hot fuel will always have to spend some amount of time in the pools, just to cool off to the point where it can be moved. But again, I—this is something that I am very confident we will be looking at as part of both the short-term and the long-term review.

Senator FEINSTEIN. Thank you. Thank you.

Mr. JACZKO. Sure.

Senator FEINSTEIN. Did you have anything you want to say or a question to ask?

Senator ALEXANDER. I wonder if Dr. Lyons agrees, from the point of view of the DOE, that used nuclear fuel can be safely stored onsite for up to 100 years.

Mr. LYONS. I was on the NRC when that question was reviewed and I was part of the decision that evaluated that information. This was before my current job. Yes, I do agree.

However, just as additional information, through the R&D program at the DOE, we also will be pursuing a program designed to understand what may be the lifetime limiting—or the life limiting aspects of how long dry casks can be safely used. So that will be another contribution to this overall discussion of the longevity of dry cask storage.

Senator FEINSTEIN. Thank you very much gentlemen. This was very helpful and we appreciate it. Thank you for being here.

Oh, I'm sorry. Senator Durbin.

Senator DURBIN. I—if I can just do one followup question, because when I raised the issue of reprocessing I thought the chairman's allusion was to the economics of it. And can any—can either of you speak to the economics of reprocessing and deriving some sort of fuel source from that and dramatically reducing the waste that is left behind, as opposed to the current cost of cooling pools, casks and ultimate national repository?

Mr. LYONS. Senator Durbin, if I may. I indicated that we do have research programs that span the gamut of different options for the back end of the fuel cycle and that certainly includes the reprocessing that you are addressing. In addition, the Blue Ribbon Commission will be providing guidance on this.

As far as the economics, I have never seen a study that claimed that it was less expensive to use reprocessing. There may be other reasons why one would want to reprocess, but I am certainly not aware of any study which says that reprocessing would be a lower-cost option, nor am I aware of any utility in this country that is pushing to move toward reprocessing. There certainly are companies for whom that is their product and would be very interested.

Yes, also you mentioned the situation in France and Japan. Let me just note that part of our research is designed to understand some of the limitations on particularly the approach that is used in Japan, the PUREX approach, which we would not utilize in this country from a number of different perspectives, including a nonproliferation concern and including environmental concerns.

Senator DURBIN. So, if I can for a second, but correct me if I'm wrong, I understood, during the debate on Yucca Mountain that it was agreed that the ultimate responsibility for storing this nuclear waste was to be borne by the government taxpayers.

Mr. LYONS. That is correct. That is the Nuclear Waste Policy Act and the Amendments Act.

Senator DURBIN. And so when you say that the commercial private sector does not support reprocessing, it would seem to me that we ought to be asking, from the taxpayer's viewpoint, whether that is an economic alternative if we are ever to build Yucca Mountain and transport the—all the waste in America to that site.

Mr. LYONS. Well, the Nuclear Waste Policy Act also requires that there be a fee levied on all nuclear power use that is intended to cover the costs of whatever back end, whatever disposition system is to be used. So whatever the costs of that will be, and currently there is a one mil per kilowatt hour assessment on nuclear power, that is intended to cover the back end. To the extent perhaps additional funds would be required for other back end systems that would be passed along.

Senator DURBIN. My last question, I am sorry Madam Chair, but taking the current French approach on reprocessing, are you saying that we have done an economic model to compare the cost of reprocessing against the cost of a national repository?

Mr. LYONS. There have been a number of such models. I certainly can't characterize all of them quickly, but I am quite sure that the majority, if not all of them would say that a repository, I am not saying economic, but a repository approach probably is a lower cost. But there may be other reasons, and this is part of the Blue Ribbon Commission review, there may be other reasons that would drive one toward some form of reprocessing. I believe it would be different than what is used in France.

Senator DURBIN. Thank you.

Mr. JACZKO. Senator, if I could perhaps clarify my reference to the economics. The economic comparison that I am referring to is the cost of fuel that would come directly from uranium that is mined in the ground as opposed to the cost of fuel that would come from reprocessed uranium. That is the economic comparison that I was referring to. And in that case right now the price of uranium generally favors the naturally mined uranium as a source of fuel. So that was the economic comparison I was referring to.

Senator FEINSTEIN. Thank you very much.

Senator LAUTENBERG. I just—Madam Chairman, your indulgence please for a question that I have that has puzzled me since you testified at an earlier hearing, Dr. Jaczko.

The NRC requires evacuation plans only for areas within 10 miles of a plant, but the United States Government has warned Americans in Japan to stay at least 50 miles away from the damaged reactors there and the ships were turned around, I think it was at 60 miles. When I asked you at the previous hearing what you thought was a safe distance, I think that the response that you gave me was 20 miles. Can we clear this up? And why not require the same kind of evacuation plan to address the same distance here at home?

Mr. JACZKO. Well, Senator, this is likely an issue we will be looking at as part of our short-term and long-term reviews, but the 10-mile distance in the United States is the distance at which we develop preplanned and prepared evacuation plans. So it is based on an event that would happen in a very short period of time for which you would not have the ability to develop additional planning for evacuations beyond a certain distance. There is always the possibility that if an event were to develop like it has in Japan, that additional protective actions could be required beyond 10 miles. But the requirements we have in place are for those—the preplanning that needs to be done so that if you got an event that happened and developed very quickly, you wouldn't have to take the time then to develop the evacuation plans, they are already developed and ready to go as soon as that event happens.

But of course as the events in Japan show, that it was something that happened over a course of many, many days before we got to the point at which we looked at information that indicated you could have to go to a great distance. So far the data coming out of the plant continues to show that the safe distance there is approximately 20 miles.

So there is the work that we do to preplan, which right now we believe 10 miles is sufficient. But that is not necessarily the end of any protective action. You could take additional action beyond that if necessary.

Mr. LAUTENBERG. We look forward to hearing from you on kind of a continuing basis to find out what a good conclusion is that you come to. Thank you.

Senator FEINSTEIN. Thank you very much, Senator.

We've been joined by Senator Graham. Would you like to make a statement or ask questions?

Senator GRAHAM. Just ask questions would be great.

Senator FEINSTEIN. Go right ahead.

Senator GRAHAM. Thank you. I am honored to be on the subcommittee.

Mr. Chairman, do you believe the nuclear power industry in the United States is well-regulated and generally safe?

Mr. JACZKO. I certainly, as the chairman of the NRC, believe it is well-regulated.

Senator GRAHAM. Okay.

Mr. JACZKO. And we do believe we have a strong program to ensure protection of public health and safety.

Senator GRAHAM. Would you advise the Congress to continue to pursue nuclear power as part of energy production in this country?

Mr. JACZKO. Well, decisions ultimately about what to do with nuclear power really are beyond our, really our responsibility.

Senator GRAHAM. Just as a citizen, would you like to see America have more nuclear power in the future?

Mr. JACZKO. I, as a citizen, would like to see nuclear power that is safe and secure and that is fundamentally my job as chairman of the NRC.

Senator GRAHAM. And do you believe that the nuclear power plants that we are talking about constructing in the future are more modern and safer?

Mr. JACZKO. Certainly the plants that are under consideration have enhanced design and enhanced safety features that at least on—at the design stage and on paper seem to indicate that they would have an inherent safety advantage over the existing plants.

Senator GRAHAM. One of the benefits——

Mr. JACZKO. But I want to stress, if I could, that we believe the plants that are in existence today do meet our requirements for safety and security and the new plants could potentially have some additional enhancements over that.

Senator GRAHAM. It is like new cars have things that old cars don't have, but we still drive older cars. I have an older car and I feel safe in it. I will buy a newer car and may be even safer, I guess.

At the end of the day, one of the big impediments—the benefit of nuclear power is it creates good jobs, in my view, and it doesn't emit pollutants in the air. Is that your understanding? I wonder if it is——

Mr. JACZKO. Well, again we—you know, the focus for the agency is really to make sure that the nuclear power that is in this country is safe and secure. And we continue to have a program, we think, that ensures that.

Senator GRAHAM. If I called it "clean energy" would you agree?

Mr. JACZKO. You know, I tend to not like to get into——

Senator GRAHAM. I see.

Mr. JACZKO [continuing]. Discussions about those kind of things.

Senator GRAHAM. Let's talk about spent fuel. Can we talk about that?

Mr. JACZKO. Sure.

Senator GRAHAM. Because I think—I didn't hear his question, but Senator Durbin is making a point about what should we do with spent fuel. I have always been a fan of the French reprocessing system, but quite frankly Secretary Chu has convinced me, and I think he is one of the best Secretary of Energy that we have ever had since I have been in the Congress. I like him a lot, incredibly smart. He has convinced me that if we will be patient, maybe in the next decade plus there will be new technologies developed on the spent-fuel reprocessing front that would be worth waiting on. Do you agree with that?

Mr. JACZKO. Well, I think again from the NRC perspective——

Senator GRAHAM. Mr. Lyons.

Mr. JACZKO [continuing]. We would just want to make sure that spent fuel can be stored safely and securely——

Senator GRAHAM. Okay.

Mr. JACZKO [continuing]. Until then. And we think that is the case right now.

Senator GRAHAM. Okay. Mr. Lyons.

Mr. LYONS. Let me start, Senator Graham, by heartily agreeing with my boss, Secretary Chu.

Senator GRAHAM. Both of you all are very smart. I like it.

Mr. LYONS. But we—yes, we are very interested in exploring a wide range of options on the back end of the fuel cycle and putting it——

Senator GRAHAM. So you think it would be beneficial for the country not to duplicate the French system right now?

Mr. LYONS. The French system uses the so-called PUREX process. They have certainly made some improvements in it over the years, but we do have some issues related to possible proliferation from that cycle as well as environmental issues. We think that with research we can do substantially better and that is the research that Secretary Chu is leading, through my office.

Senator GRAHAM. Is shutting Yucca Mountain down helpful to our nuclear waste problem or harmful?

Mr. LYONS. Let me answer in this way, Senator. I came to the Department after the decision had been made and I heartily agreed with the Secretary that Yucca Mountain is not a workable solution, because I believe that the equation needs both a technical and a local support. As a resident of Nevada for many years I saw the lack of local support. I do think it is possible, and certainly the Blue Ribbon Commission is working toward approaches that may not only provide interesting technical options, but I hope can be done in ways, like it has been done in many international venues, with strong, local support.

Senator GRAHAM. Okay. Thank you. I think that is the key to this is probably local political support more than anything else.

But we will just move on right quickly to MO_X fuel. Can you tell us what MO_X—did MO_X fuel in any way contribute to the disaster in Japan?

Mr. LYONS. No.

Senator GRAHAM. We have a program to create MO_X fuel in America that would take plutonium weapons and convert them into plowshares; it is called The MO_X Program at Savannah River, South Carolina. Do you support that?

Mr. LYONS. Yes, sir. That is not through my program, however, yes, I am well aware of the program. And that is through NNSA, the defense——

Senator GRAHAM. If I could just indulge my colleagues a moment. There are 34 metric tons of weapons-grade plutonium that are in excess of our defense needs here and the equivalent amount in Russia. And these are literally nuclear weapons. And there is a process called MO_X where you can take the weapon and dilute it down and create commercial fuel. You are literally taking a sword and turning it into a plowshare. And that program is going on in South Carolina at the Savannah River site.

And I just want to thank the administration for being supportive of the program. And there are some things being said in the House about the MO_X Program I would like to get straight. Again, do you believe that producing MO_X fuel here in America makes sense, it is overall safe and do you recommend we continue to do so?

Mr. LYONS. Well again sir, when we cross to safety I need to pass it back to Greg. I certainly understand the nonproliferation aspects of this. And——

Senator GRAHAM. It is huge, isn't it?

Mr. LYONS. Yes, sir.

Senator GRAHAM. It is huge. I mean you are literally taking weapons grade plutonium off the market and doing something constructive with it.

Mr. Chairman, do you support the MO_X Program?

Mr. JACZKO. Well, we have done very thorough analyses of the use of MO_X fuel and right now we—all the information we have indicates that it can be used safely.

Senator GRAHAM. Thank you very much for your testimony.

Senator FEINSTEIN. Thank you very much, Senator Graham.

Gentlemen, thank you so much. We will proceed to the next panel.

I would ask the witnesses to come forward as quickly as you can and staff to change the name cards.

We will begin with Dr. Moniz of MIT. Thank you, sir, for being here. The clock will run in 5-minute allocations. We review your written statements so if you could summarize and we can have a more informal discussion I think that would be most useful.

You have heard the prior panel. We would be interested on your reactions and reflections.

STATEMENT OF DR. ERNEST J. MONIZ, PROFESSOR OF PHYSICS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. MONIZ. Madam Chairman, Ranking Member Alexander, thanks again—thanks for the opportunity to present and discuss some views on the development of nuclear power in the United States in the wake of the Fukushima events.

I must start by emphasizing that my testimony is purely my personal view, not the view of PCAST, the Blue Ribbon Commission or MIT.

Fukushima has reopened the global discussion about the future of nuclear power, but we clearly don't know how this debate will end. However, I think some outcomes are a very good bet. The cost of doing business at nuclear reactors will go up; the expected relicensing of 40-year-old nuclear plants for another 20 years will face additional scrutiny. These plants, like those at Fukushima, rely to a large extent on active safety systems rather than the passive safety systems built into the new designs. And the third, the options for the entire spent-fuel management system I expect will be re-evaluated.

Let me selectively address a few of these issues. First cost. Currently operating plants would certainly face a very expensive proposition to retrofit if design threats are elevated substantially. This calls for a plant-by-plant review, of course including specific circumstances, like seismic. In many cases however, perhaps most, I expect the design basis threats are likely to be deemed sufficiently conservative and remain unchanged.

The regulatory decisions about safety requirements can be assisted by application of new capabilities, among them the kind of advanced modeling and simulation tools being developed at DOE's first innovation hub at Oak Ridge, and I might say, with major MIT engagement. Other types of retrofits could be more easily absorbed into normal operations such as transitioning the silicon-carbide fuel cladding to get higher-safety margins. I believe that the slow pace of this indicates, historically, an R&D program poorly aligned with strategic priorities, but the DOE current roadmap I think is a big step in the right direction.

Now new nuclear power plants are already challenged, let's face it, by high capital costs and increased costs—capital or operating—could tip the balance for many projects, depending on many financing and cost recovery factors. Now reducing the financial risk premium for nuclear power is a major objective of government support for first mover plants, principally through the loan guarantee program. Fukushima clearly does not help in this regard.

An entirely different approach to new plants lies with SMRs and these could be a powerful way to address the cost issue by moving us from economies of scale to economies of manufacturing. But I do want to say, and I am very enthusiastic about these, but I do want to say there is a catch-22 that these economies of manufacture can only be realized, presumably, if we have a sufficient stream of orders for a greatly winnowed down set of technology options and that will be a complex interplay of government and the many proponents of and customers for the currently contending numerous SMR designs.

Prior to Fukushima the administration submitted a budget for 2012 that would have greatly enhanced the level of activity for bringing SMRs to market. I believe that program is modest, but sensible and deserves support.

Second, relicensing decisions of the NRC will almost certainly experience some delay. If the anticipated life extensions are not realized at any appreciable degree, we have to face the issue of replacing potentially tens of thousands of megawatts of nonemitting generation. It is not an immediate problem, because of our natural gas situation, but if we want to have those zero emission options for 2020, it is an immediate challenge to develop them. And I do want to emphasize, among those options we must retain next-generation nuclear plants with advanced safety systems, including SMRs.

Third, spent-fuel management, the Fukushima problems with spent-fuel pools co-located with reactors will undoubtedly lead to a re-evaluation of spent-fuel management strategy. Our reports at MIT have advocated, well before this, we should be moving, in any case, to consolidated spent-fuel storage. This has many drives, among them resolution of the Federal liability issues for not moving spent fuel away from reactors. And I believe that the Congress should allow use of the waste fund for development of consolidated storage.

PREPARED STATEMENT

But eventually the spent fuel must go to a repository. My view is—my recommendation in the end is that consolidated spent fuel dry cask storage be established as soon as possible, as I discussed, and that a geological repository be established as soon as possible for defense high-level waste and spent fuel. That is, I would argue going back, re-evaluating the 1980s decision of commingling defense and civilian waste, separate them. Because I believe, for many reasons, we can move much faster toward a defense waste repository which would in turn develop tremendous amounts of knowledge and experience for an ensuing civilian waste repository.

Thank you and I look forward to the discussion.

[The statement follows:]

PREPARED STATEMENT OF DR. ERNEST J. MONIZ

FUKUSHIMA AND DIRECTIONS FOR U.S. NUCLEAR POWER

Chairman Feinstein, Senator Alexander, and members of the subcommittee, thank you for the opportunity to present and discuss views on the development of nuclear power in the United States in the wake of the Fukushima events. I must start by emphasizing that this testimony represents my personal views, not those of the President's Council of Advisors on Science and Technology, the Blue Ribbon Commission on America's Nuclear Future, or my home institution, Massachusetts Institute of Technology (MIT).

Fukushima has reopened the global discussion about the future of nuclear power. Several factors had led many countries to consider expanding their nuclear capacity, reversing phaseouts, or initiating new nuclear programs. These factors include a very good safety and reliability record for the last decades, increasing concern about the risks of climate change, and a concomitant recognition that enormous amounts of additional electric generating capacity will be needed without increasing greenhouse gas and other polluting emissions. Exactly how the new debate will end is unclear and will remain so for some time, as the events and responses in Japan are investigated and fully understood, and as safety systems, operating procedures, regulatory oversight, emergency response plans, design basis threats, and spent-fuel management are re-examined by the Nuclear Regulatory Commission (NRC) for currently operating United States reactors.

Nevertheless, some outcomes are a good bet:

—The cost of doing business at nuclear reactors will go up, reflecting factors as diverse as new requirements for onsite spent-fuel management to measures needed to address possible elevated design basis threats.

—The expected relicensing of 40-year-old nuclear plants for another 20 years of operation will face additional scrutiny, taking more time than expected. Indeed some of the license extensions already granted for more than 60 of the 104 plants operating in the United States could be revisited. These plants, like those at Fukushima, rely to a large extent on active safety systems in case of accidents or natural disasters, rather than the passive safety systems built into the new designs.

—Options for the entire spent-fuel management system—onsite storage, consolidated long-term storage, geological disposal—will be re-evaluated. This will be based both on what we learn from the Fukushima investigations about the spent-fuel behavior under accident conditions to a broader imperative to rationalize our overall SNF management system.

The consequences of such outcomes could be very significant for nuclear power and for the entire energy system. We shall selectively address some of the associated issues.

COST

Currently operating nuclear plants would face an expensive proposition to retrofit if design threats are elevated substantially. On the positive side, nuclear power plants have low-operating and fuel costs compared with coal and natural gas plants, and the owners might be able to absorb reasonable costs. However, the business decisions would be on a plant-by-plant basis depending on the design basis threat assigned to the plant's specific circumstances (e.g., seismic). In many cases, perhaps most, the design basis threats are likely to be deemed sufficiently conservative and remain unchanged. The regulatory decisions about safety requirements can be assisted by application of new capabilities, such as advanced large-scale modeling and simulation. The first of DOE's innovation hubs, located at Oak Ridge (with MIT as a major partner) is dedicated to developing related computational tools over the next several years.

Other types of retrofits could be more easily absorbed into normal operations. For example, there has long been a discussion of transitioning to silicon-carbide fuel cladding in order to gain higher safety margins and other operational benefits as well. The cladding can be formed into the same size and shape as zircaloy cladding used in currently operating reactors, but has much less reactivity with steam (this was the source of the hydrogen in the Fukushima loss-of-coolant situation). But, long after this was proposed and investigated, we are still several years from evaluation in commercial reactors, and widespread adoption will take many more years. This timetable reflects a history of underfunded R&D programs that have been poorly aligned with strategic priorities. Last year's DOE R&D roadmap is a step in the right direction.

New nuclear power plants are already challenged by high capital costs, and increased capital and operating costs could tip the balance for many projects, depending on many financing and cost recovery factors. The costs are illustrated in the table showing levelized electricity costs for new plant construction. This is taken from a 2010 MIT report on the Future of the Nuclear Fuel Cycle. Today's natural gas prices are in the $4–$5/MBtu range, making natural gas plants much more economical with respect to both capital requirements and levelized electricity cost. However, we have been through many significant excursions in natural gas prices over the last decade, resulting in caution about committing to only one fuel source. The generation portfolio decisions are likely to be different in different parts of the country according to the integrated resource planning methodology of public utility commissions, the availability of infrastructure, the ability to incorporate costs into a rate base, generation portfolio standards, and State/regional carbon dioxide emissions requirements.

COSTS OF ELECTRIC GENERATION ALTERNATIVES

[2007 dollars]

	Overnight cost ($/kW)	Fuel cost ($/MBtu)	Levelized cost of electricity (cents/kW)		
			Base case	$25/ton-$CO_2$ price	Same cost of capital
Nuclear	4,000	0.67	8.4	8.4	6.6
Coal	2,300	2.60	6.2	8.3	
Gas	850	4/7/10	4.2/6.5/8.7	5.1/7.4/9.6	

Modest carbon dioxide emissions charges would make nuclear competitive with coal. A major factor is the cost of capital, which hits nuclear power plant construction particularly hard because of the high capital costs and the longer construction times that are typically required. Reducing the financing risk premium for nuclear power is a major objective of Government support for "first mover" nuclear power plants, principally through the loan guarantee program first put in place in the Energy Policy Act of 2005. The events of Fukushima clearly do not help in this regard.

An entirely different approach to new nuclear power plant construction lies with small modular reactors (SMRs). This could be a powerful way to address the cost issue. SMRs come in a variety of proposed forms, some based on the same underlying light water reactor (LWR) technology that is used in almost all nuclear plants today, while others are based on gas- or metal-cooled designs. They range in size from 10 to 300 megawatts. None have been through a licensing procedure at the NRC, and this is a time consuming process for any new nuclear technology—especially those that are farther away from the NRC's established experience and procedures.

A major advantage of SMRs is that their small size compared with LWRs (whose size is typically 1,000 megawatts and now going up to 1,600 megawatts) means that the total capital cost is more in the $1 billion range rather than a significant multiple of that. Capacity can be built up with smaller bites, and this may lead to more favorable financing terms—a major consideration for high capital cost projects that take years to license and build. Still, the SMR must come in with a cost that is also competitive with LWRs on a unit basis; that is, the cost per installed Megawatt must be comparable or less. The LWRs have been driven to larger and larger size in order to realize economies of scale. The SMRs may be able to overcome this trend by having factory construction of the SMR or at least of its major components, presumably with economies of manufacturing, the ability to train and retain a skilled workforce at manufacturing locations, quality assurance, continuous improvement, and only fairly simple construction onsite. The catch-22 is that the economies of manufacture will presumably be realizable only if there is a sufficiently reliable stream of orders to keep the manufacturing lines busy, and this in turn is unlikely unless the large number of designs is winnowed down fairly early in the game. Reaching the n-th plant for a small number of reactor types is likely to require a complex interplay between Government support and proponents of the many contending SMR designs.

A 2020 SMR option will be available only if we start now, and even then it will be tight. Prior to Fukushima, the Obama administration submitted to the Congress a proposed 2012 budget that would greatly enhance the level of activity in bringing SMRs to market. LWR-based technology options would be advanced toward licensing, and other SMR technologies would be supported for the remaining R&D needed to have them follow in the licensing queue. The program is modest, but sensible. Obviously the Federal budget deficit makes it difficult to start any new programs, but a hiatus in creating new clean energy options—be it nuclear SMRs or renewables or advanced batteries—will have us looking back in 10 years lamenting the lack of a technology portfolio needed to meet our energy and environmental needs economically or to compete in the global market.

RELICENSING

Relicensing decisions at the NRC will almost certainly experience some delay. A measured approach is appropriate since the NRC is constantly monitoring plant operations and safety margins; the 40 year licensing period does not represent any particular milestone with regard to the reactor systems themselves.

If the anticipated life extensions are not realized to any appreciable degree, we will be faced with replacing tens of thousands of Megawatts of nonemitting generation. For the United States, this is not an immediate problem since the end of the original 40-year reactor operating periods will not be reached for most plants for a while, and we have both substantially underutilized natural gas generation and lots of natural gas. Natural gas does have emissions, but far less than coal, and will serve as a bridge to a very low emissions future. However, the challenge of developing and demonstrating "no-emissions" options for 2020 and beyond is immediate, given the significant timeline from R&D to regulatory approval to market.

Next-generation nuclear plants with advanced passive safety systems are among those options. This includes, but is not limited to, SMRs. The fact remains that nuclear power is the "emission-free" baseload generation technology that is, in principle, scalable without problems of variability and intermittency. Clearly, a rigorous design certification and licensing process will be needed to assure public confidence.

SPENT-FUEL MANAGEMENT

The Fukushima problems with spent-fuel pools co-located with the reactors will undoubtedly lead to a re-evaluation of spent nuclear fuel (SNF) management strategy. There is no need to act precipitously, but the fact is that our overall waste disposal system is fundamentally broken and needs re-examination in any case (as is being done by the Blue Ribbon Commission).

The MIT "The Future of Nuclear Power" report in 2003 and the MIT Future of the Nuclear Fuel Cycle summary report in 2010 called for consolidated spent-fuel storage (these reports can be accessed at web.mit.edu/mitei). There are many reasons for this quite independent of the Fukushima experience. The 2010 report made a recommendation (pg xi):

"Planning for long-term managed storage of spent nuclear fuel—for about a century—should be an integral part of nuclear fuel cycle design. While managed storage is believed to be safe for these periods, an R&D program should be devoted to confirm and extend the safe storage and transport period.

"The possibility of storage for a century, which is longer than the anticipated operating lifetimes of nuclear reactors, suggests that the United States should move toward centralized SNF storage sites—starting with decommissioned reactor sites and in support of a long-term SNF management strategy."

The consolidated storage recommendation has many drivers:

—The SNF would be stored in dry casks. There is no need for the SNF to be located at the reactor site, as the operational requirements are quite different; for example, the reactor needs access to large amounts of cooling water, while the SNF storage system does not.

—Issues such as the Federal liability for not moving SNF from reactor sites would be resolved.

—A degree of opposition to expanding nuclear power would be addressed by moving the fuel to a consolidated secure location, most likely under Federal control (this does not rule out privately developed sites under NRC license).

—While the risks of cascading failures are extremely small, the Fukushima incident showed that the probability is not zero. The spent fuel, which contains considerable radioactivity and needs cooling, would be mostly removed from the reactor site in case of a major accident or natural disaster (the SNF recently removed from the reactor core would still need some cooling time in a pool).

—"Densification" of spent fuel in pools beyond the original design density should not be necessary.

The Congress should allow use of the waste fund for development of consolidated storage.

Eventually, the SNF, or the high-level waste (HLW) that would result from a future decision to reprocess, would need to go to a geological repository. Indeed, the intermediate step of consolidated dry-cask storage could be eliminated if a repository were in place to accept the SNF. However, there is still a debate about whether SNF is a waste or a valuable energy resource to be harvested by reprocessing. The uncertainty has multiple origins. One is that the trajectory of nuclear power deployment is not clear. If nuclear power does not grow, it is unlikely that reprocessing will be attractive. However, even if nuclear power does grow, it is not obvious that reprocessing is the preferred path; for example, a new generation of recycling reactors might be started with enriched uranium rather than plutonium recovered from reprocessing. This uncertainty argues for maintaining options by committing to century-scale consolidated storage for commercial SNF, as recommended above, while pursuing geological repository development in parallel. The arduous and time-consuming process needed to establish and utilize one or more geological repositories for the growing amount of power reactor SNF calls for renewed commitment even as consolidated storage is established. These are core results of the MIT analysis of fuel cycle options.

Going beyond those studies, I suggest that the decision to co-mingle defense and civilian nuclear wastes should be revisited. The conditions today are much different from when the co-mingling decision was put forward in 1985. In particular, the timeline for establishing a commercial spent-fuel repository is evidently much longer than anticipated at that time.

—The defense wastes are small compared with civilian wastes and are essentially bounded (there is a small amount of additional SNF each year from the naval nuclear propulsion program).
—Much of the waste is very old and therefore relatively cool.
—There is no argument about a possible energy value; all agree that it is waste to be disposed of, so there is no need to preserve options through longer-term storage.
—There are agreements with the affected States to remove the fuel, and these are important for continuing nuclear defense missions at these sites.
—A separate defense repository, while still subject to NRC licensing, would have simpler finances going forward, although a reconciliation would be needed with the civilian program that recognized the defense financial contributions to the development of Yucca Mountain.
—Responsibility would reside with the DOE as a Government function to dispose of waste generated in an inherently governmental enterprise—the development of nuclear weapons.
—At the same time, a future commercial SNF/HLW repository would not have the complication of dealing with national defense HLW and SNF.

The recommendation is that consolidated SNF dry-cask storage be established as soon as possible at one or a few sites for commercial power reactor fuel and that a geological repository be established as soon as possible for defense HLW/SNF. A commercial repository would be pursued in parallel, but most likely in a longer timeframe given the current realities. The defense waste repository would provide invaluable knowledge and experience for the civilian waste repository.

In summary, while it is too early to understand the causes and full implications of the Fukushima events, it is not too early to start thinking about the cost, relicensing, and SNF management issues that will inevitably arise and influence the future of nuclear power. These deliberations should be carried out in a measured way.

Thank you again for the opportunity to present these views. I look forward to a discussion.

Senator FEINSTEIN. Thank you very much, Dr. Moniz.

Mr. Levis.

STATEMENT OF WILLIAM LEVIS, PRESIDENT AND CHIEF OPERATING OFFICER, PSEG POWER

Mr. LEVIS. Chairman Feinstein, Ranking Member Alexander, thank you for the opportunity to appear before you today.

My name is William Levis; I am the president and chief operating officer of PSEG Power which is a subsidiary of Public Service Enterprise Group headquartered in Newark, New Jersey. PSEG Power is a merchant generating company and owns approximately 14,000 megawatts of electric generating capacity. We own 100 percent of the Hope Creek Nuclear Station, 57 percent of the Salem Nuclear Station and 50 percent of the Peach Bottom Station.

I appreciate your invitation to testify at today's hearing to discuss the status of the U.S. nuclear energy industry and the implications of the Fukushima nuclear accident on nuclear energy in the United States. I am testifying today on behalf of the Nuclear Energy Institute, the nuclear energy industry's Washington based policy organization.

My remarks today will cover four points. First, U.S. nuclear power plants are safe. Second, safety is the U.S. nuclear energy industry's top priority. Third, the U.S. nuclear energy industry has a long history of continuous learning from operational events; we will do the same as a result of the Fukushima event. And fourth, the U.S. nuclear energy industry has already taken proactive steps to verify and validate our readiness to manage extreme events. We took these steps early without waiting for clarity on the sequence of failures of Fukushima.

Regarding the first point, U.S. nuclear power plants are safe. They are designed and operated conservatively to manage the maximum credible challenges appropriate to each nuclear plant site. U.S. nuclear power plants have also demonstrated their ability to maintain safety through extreme conditions, including floods, hurricanes, and other natural disasters.

U.S. nuclear reactors are designed to withstand earthquakes, tsunamis, hurricanes, floods, tornados, and other natural events equal to the most significant historical event or maximum projected event, plus added margin for conservatism without any breach of safety systems.

Regarding the second point, safety is the nuclear energy's industry's top priority and complacency about safety performance is not tolerated. We know we operate in an unforgiving environment where the penalties for mistakes are high and where credibility and public confidence, once lost, are difficult to recover. All the safety related metrics tracked by industry and the NRC demonstrate high levels of excellence. Forced outage rates, unplanned safety system actuations, worker radiation exposures, events with safety implications, and lost-time accident rates have all trended down year over year for a number of years.

Regarding the third point, the U.S. nuclear industry routinely incorporates lessons learned from operating experience into its reactor designs and operations. I could point to many, many examples of improvements made to the U.S. nuclear power plants over the years in response to lessons learned from operational events over the last 40 years. Let me just list a few.

In the 1970s concerns were raised about the ability of Boiling Water Mark 1 containments to maintain its design during an event where steam is vented to the torus. Subsequently, every United States operator with a Mark 1 containment implemented modifications to dissipate energy released to the suppression pool and installed stringent supports to accommodate loads that could be generated.

In 1988, the NRC concluded that additional Station Blackout (SBO), regulatory requirements were justified and issued the Station Blackout Rule to provide further assurance that a loss of both offsite and onsite emergency AC power systems would not adversely impact public health and safety. The SBO Rule was based on several planned, specific probabilistic safety studies, operating experience and reliability, accident sequence, and consequent analysis completed between 1975 and 1988.

And third, since the terrorist events of September 11, 2001, U.S. nuclear plant operators identified other beyond design basis vulnerabilities. As a result, U.S. nuclear plant designs and operating practices since 9/11 are designed to mitigate severe accident scenarios such as aircraft impact, which includes the complete loss of offsite power and all onsite emergency power sources and loss of large areas of plant. The industry developed additional methods and procedures to provide cooling to the reactor and the used fuel pool and staged additional equipment at all U.S. nuclear power plant sites to ensure that the plants were equipped to deal with extreme events and nuclear plant operation staffs are trained to manage them.

Regarding the final point, the United States nuclear industry has already started an assessment of events in Japan and is taking steps to ensure that United States reactors could respond to events that may challenge safe operation of the facilities. These actions include: verifying each plant's capability to manage severe accident scenarios developed after 9/11 that I previously described; verifying each plant's capability to manage a total loss of offsite power; verifying the capability to mitigate flooding and the impact of floods on systems inside and outside the plant and performing walk downs and inspections of important equipment needed to respond successfully to extreme events like fires and floods.

PREPARED STATEMENT

In conclusion, Madam Chairman, it will be some time before we understand the precise sequence of what happened at Fukushima, before we have a complete analysis of how the reactors performed, how equipment and fuel performed, how the operators performed. As we learn from this tragic event, however, you can rest assured that we will internalize those lessons and incorporate them into our designs and training and operating procedures.

This concludes my oral testimony, Madam Chairman, and I look forward to answering questions that the committee may have.

[The statement follows:]

PREPARED STATEMENT OF WILLIAM LEVIS

Chairman Feinstein, Ranking Member Alexander, and members of the subcommittee, thank you for the opportunity to appear before you today.

My name is William Levis. I am president and chief operating officer of PSEG Power which is a subsidiary of Public Service Enterprise Group, headquartered in Newark, New Jersey. PSEG Power is a merchant generating company and owns approximately 14,000 megawatts of electric generating capacity. We own 100 percent of the Hope Creek nuclear generating station, 57 percent of the Salem nuclear station, and 50 percent of the Peach Bottom nuclear station. PSEG Power operates Salem and Hope Creek; Exelon operates Peach Bottom. Salem consists of two pressurized water reactors; Hope Creek is a single boiling water reactor; the Peach Bottom station has two boiling water reactors.

I appreciate your invitation to testify at today's hearing to discuss the status of the U.S. nuclear energy industry and the implications of the Fukushima nuclear accident on nuclear energy in the United States. I am testifying today on behalf of the Nuclear Energy Institute, the nuclear energy industry's Washington-based policy organization. NEI members include all companies licensed to operate commercial nuclear powerplants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

My remarks will cover four major points:

First, U.S. nuclear powerplants are safe.

Second, safety is the U.S. nuclear energy industry's top priority.

Third, the U.S. nuclear energy industry has a long history, over several decades, of continuous learning from operational events, and we have incorporated lessons learned into our nuclear plant designs and our operating practices and training. We will do the same as a result of the Fukushima accident.

And fourth, the U.S. nuclear energy industry has already taken pro-active steps to verify and validate our readiness to manage extreme events. We took these steps early—without waiting for clarity on the sequence of failures at Fukushima.

Before I address these four points, however, let me note that the U.S. nuclear energy industry works very hard not to grow complacent about safety. This is not always easy when our 104 nuclear powerplants are operating well, with an average capacity factor above 90 percent for the last 10 years. Similarly, we cannot be complacent about the accident at Fukushima. I cannot tell you at this moment whether or not we will discover previously unknown vulnerabilities at America's nuclear powerplants, but I am quite confident that we will learn important lessons from Fukushima and identify additional steps we can and will take to further improve the margin of safety at our nuclear plants.

U.S. NUCLEAR POWERPLANTS ARE SAFE

That said, we do believe U.S. nuclear powerplants are safe. They are designed and operated conservatively to manage the maximum credible challenges appropriate to each nuclear power plant site. U.S. nuclear powerplants have also demonstrated their ability to maintain safety through extreme conditions, including floods and hurricanes and other natural disasters.

I can think of no better summary of the status of U.S. nuclear powerplants than the one delivered by President Obama to the American people on March 17. Mr. Obama said: "Our nuclear powerplants have undergone exhaustive study, and have been declared safe for any number of extreme contingencies. But when we see a crisis like the one in Japan, we have a responsibility to learn from this event, and to draw from those lessons."

We invest heavily in our operating plants to ensure safe, reliable operation. The U.S. nuclear energy industry invested approximately $6.5 billion in 2009 in our 104 operating plants—to replace steam generators, reactor vessel heads and other equipment and in other capital projects.

U.S. nuclear reactors are designed to withstand earthquakes, tsunamis, hurricanes, floods, tornadoes and other natural events equal to the most significant historical event or the maximum projected event, plus an added margin for conservatism, without any breach of safety systems. We have many, many examples of U.S. nuclear powerplants achieving safe shutdown during extreme events where offsite power was lost. During Hurricane Katrina in 2005, for example, the Waterford nuclear power plant in Louisiana shut down safely, lost all offsite power, and maintained safe shutdown on emergency diesel generators for 3½ days until grid power was restored.

For earthquakes, nuclear plants are designed and constructed to withstand the maximum projected earthquake that could occur in its area, with additional margin added. Plant earthquake-induced ground motion is developed using a wide range of data and review of the impacts of historical earthquakes up to 200 miles away. Those earthquakes within 25 miles are studied in great detail. This research is used to determine the maximum potential earthquake that could affect the site. Each reactor is built to withstand the respective strongest earthquake; for example, a site that features clay over bedrock will respond differently during an earthquake than a hard-rock site.

It is important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations. The Tohoku earthquake that struck the Fukushima nuclear power plant occurred on a "subduction zone," the type of tectonic region that produces earthquakes of the largest magnitude. A subduction zone is a tectonic plate boundary where one tectonic plate is pushed under another plate. Subduction zone earthquakes are also required to produce the kind of massive tsunami seen in Japan.

In the continental United States, the only subduction zone is the Cascadia subduction zone which lies off the coast of northern California, Oregon, and Washington. In an assessment released last week, the California Coastal Commission concluded that a "nuclear emergency such as is occurring in Japan is extremely unlikely at the State's two operating nuclear powerplants. The combination of strong ground motion and massive tsunami that occurred in Japan cannot be generated by faults near the San Onofre Nuclear Generating Station and the Diablo Canyon Power Plant."

SAFETY IS THE U.S. NUCLEAR ENERGY INDUSTRY'S TOP PRIORITY

This leads to my second point: Safety is the U.S. nuclear energy industry's top priority, and complacence about safety performance is not tolerated.

We know we operate in an unforgiving environment where the penalties for mistakes are high and where credibility and public confidence, once lost, are difficult to recover.

All of the safety-related metrics tracked by industry and the Nuclear Regulatory Commission (NRC) demonstrate high levels of excellence. Forced outage rates, unplanned safety system actuations, worker radiation exposures, events with safety implications, and lost-time accident rates have all trended down, year over year, for a number of years.

We can have confidence in nuclear plant safety based on those indicators, but we should derive even greater confidence from the process that produces those indicators, from the institutions we have created to share best practices, to establish standards of excellence and to implement programs that hold us to those standards.

After the 1979 accident at Three Mile Island, the nuclear industry created the Institute of Nuclear Power Operations (INPO). In INPO, the nuclear industry—unique among American industries—has established an independent form of self-regulation through peer review and peer pressure. In fact, the President's Oil Spill Commission, in its report on the Deepwater Horizon accident, identified INPO as the model for self-regulation by the offshore oil and gas industry.

INPO is empowered to establish performance objectives and criteria, and nuclear operating companies are obligated to implement improvements in response to INPO findings and recommendations. At its headquarters in Atlanta, INPO has some 350 people monitoring nuclear plant operations and management on a daily basis. INPO evaluates every U.S. nuclear plant every 2 years, and deploys training teams to provide assistance to companies in specific areas identified as needing improvement during an evaluation.

INPO provides management and leadership development programs, and manages the National Academy of Nuclear Training, which conducts formal training and accreditation programs for those responsible for reactor operation and maintenance.

Among its many activities, INPO maintains an industrywide database called Equipment Performance and Information Exchange (EPIX)—for —and all companies are required to report equipment problems into EPIX. EPIX catalogues equipment problems and shows, for example, expected mean time between failures, which allows the industry to schedule predictive and preventive maintenance, replacing equipment before it fails, avoiding possible challenges to plant safety. INPO also maintains a system called Nuclear Network that allows companies to report and share information about operating events, to ensure that an unexpected event at one reactor is telegraphed to all, to ensure that an event at one plant is not repeated elsewhere, to ensure high levels of vigilance and readiness.

It may not be obvious to the outside world, but we have an enormous self-interest in safe operations. We preserve and enhance the asset value of our 104 operating plants first and foremost by maintaining focus on safety. Safety is the basis for regulatory confidence, and for political and public support of this technology.

THE U.S. NUCLEAR ENERGY INDUSTRY HAS A LONG HISTORY OF CONTINUOUS LEARNING

My third point: The U.S. industry routinely incorporates lessons learned from operating experience into its reactor designs and operations. U.S. nuclear powerplants have implemented numerous plant and procedural improvements over the past 30 years. Some of these improvements have been designed to mitigate severe natural and plant-centered events similar to those experienced at the Fukushima nuclear power plant. In addition, the equipment and procedures could be used to mitigate other severe abnormal events. The type of events include a complete and sustained loss of AC power, a sustained loss of vital cooling water pumps, major fires and explosions that would prevent access to critical equipment, hydrogen control and venting, and loss of multiple safety systems.

Starting in the 1990s, U.S. nuclear powerplants developed guidelines to manage and mitigate these severe events that are beyond the normal design specifications. Plants evaluated site-specific vulnerabilities and implemented plant and procedural improvements to further improve safety. These severe accident management guidelines were developed in response to probabilistic risk assessments (PRAs), which identified several high-risk accident sequences. These guidelines provide operators and emergency managers with pre-determined strategies to mitigate these events The strategies focus on protecting the containment as it assumes the fuel clad and reactor cooling system are lost.

I could point to many, many examples of improvements made to U.S. nuclear powerplants over the years in response to lessons learned from operational events. Let me list just a few:

—In the 1970s, concerns were raised about the ability of the BWR Mark I containment to maintain its design during an event when steam is vented to the torus. Subsequently, every U.S. Operator with a Mark I containment implemented modifications to dissipate energy released to the suppression pool and stringent supports to accommodate loads that could be generated.

—As a result of the Three Mile Island accident, the industry made significant improvements to control room configuration and operator training. After that accident, which underscored the need for information to be better displayed in control rooms, all U.S. nuclear powerplants installed safety parameter display systems. A safety parameter display system collects and displays critical safety information at a workstation in the control room and other locations in the plant. Information on the status of key conditions, such as reactor core cooling, is displayed in a clear format on a computer screen. The information displayed enables the nuclear plant operators to assess plant conditions rapidly and take corrective actions. Before the accident at Three Mile Island, many U.S. nuclear powerplants trained their operators on generic simulators located offsite. Today, every U.S. nuclear reactor has a reactor-specific simulator onsite, with one shift of operators always in training. Finally, our current emergency preparedness programs grew from the lessons we learned at TMI and we now routinely drill with our State and local emergency management agencies to ensure we can appropriately communicate with the public during emergencies.

—In 1988, the NRC concluded that additional Station Black Out (SBO) regulatory requirements were justified and issued the Station Black Out rule (10 CFR 50.63) to provide further assurance that a loss of both offsite and onsite emergency AC power systems would not adversely affect public health and safety. The SBO rule was based on several plant-specific probabilistic safety studies; operating experience; and reliability, accident sequence, and consequence analyses completed between 1975 and 1988.

—Since the terrorist events of September 11, 2001, U.S. nuclear plant operators identified other beyond-design-basis vulnerabilities. As a result, U.S. nuclear plant designs and operating practices since 9/11 are designed to mitigate severe accident scenarios such as aircraft impact, which include the complete loss of offsite power and all onsite emergency power sources and loss of large areas of the plant. The industry developed additional methods and procedures to provide cooling to the reactor and the spent-fuel pool, and staged additional equipment at all U.S. nuclear power plant sites to ensure that the plants are equipped to deal with extreme events and nuclear plant operations staff are trained to manage them.

THE U.S. NUCLEAR ENERGY INDUSTRY HAS ALREADY TAKEN STEPS IN RESPONSE TO FUKUSHIMA

The United States nuclear energy industry has already started an assessment of the events in Japan and is taking steps to ensure that United States reactors could respond to events that may challenge safe operation of the facilities. These actions include:

—Verifying each plant's capability to manage major challenges, such as aircraft impacts and losses of large areas of the plant due to natural events, fires or explosions. Specific actions include testing and inspecting equipment required to mitigate these events, and verifying that qualifications of operators and support staff required to implement them are current.

—Verifying each plant's capability to manage a total loss of offsite power. This will require verification that all required materials are adequate and properly staged and that procedures are in place, and focusing operator training on these extreme events.

—Verifying the capability to mitigate flooding and the impact of floods on systems inside and outside the plant. Specific actions include verifying required materials and equipment are properly located to protect them from flood.

—Performing walk-downs and inspection of important equipment needed to respond successfully to extreme events like fires and floods. This work will include analysis to identify any potential that equipment functions could be lost during seismic events appropriate for the site, and development of strategies to mitigate any potential vulnerabilities.

Until we understand clearly what has occurred at the Fukushima Daiichi nuclear powerplants, and any consequences, it is difficult to speculate about the long-term impact on the U.S. nuclear energy program. The U.S. nuclear industry, NRC, the Institute of Nuclear Power Operations, the World Association of Nuclear Operators and other expert organizations in the United States and around the world will conduct detailed reviews of the accident, identify lessons learned (both in terms of plant operation and design), and we will incorporate those lessons learned into the design and operation of U.S. nuclear powerplants. When we fully understand the facts surrounding the event in Japan, we will use those insights to make nuclear energy even safer.

In the long-term, we believe that the U.S. nuclear energy enterprise is built on a strong foundation:

—Reactor designs and operating practices that incorporate a defense-in-depth approach and multiple levels of redundant systems;

—A strong, independent regulatory infrastructure, which includes continuous assessment of every U.S. reactor by the NRC, with independent inspectors permanently onsite and additional oversight from NRC regional offices and headquarters;

—A transparent regulatory process that provides for public participation in licensing decisions; and

—A continuing and systematic process to identify lessons learned from operating experience and to incorporate those lessons.

In conclusion, Madam Chairman, let me leave you with a short-term and a longer-term perspective.

In the short term, all of us involved with the production of electricity from nuclear energy in the United States stand in awe of the commitment and determination of our colleagues in Japan, as they struggle to bring these crippled reactors to safe shutdown.

In the longer term, it will be some time before we understand the precise sequence of what happened at Fukushima, before we have a complete analysis of how the reactor performed, how equipment and fuel performed, how the operators performed. As we learn from this tragic event, however, you may rest assured that we will internalize those lessons and incorporate them into our designs and training and operating procedures.

Senator FEINSTEIN. Thank you very much, Mr. Levis.

Mr. Lochbaum.

STATEMENT OF DAVID LOCHBAUM, DIRECTOR, NUCLEAR SAFETY PROJECT UNION OF CONCERNED SCIENTISTS

Mr. LOCHBAUM. Good morning, Madam Chairman and Ranking Member Alexander. I appreciate this opportunity to travel up here from Chattanooga, Tennessee to provide my testimony today.

Among the many challenges workers faced at Fukushima Daiichi Nuclear Plant was a need to provide cooling for radiated fuel in seven onsite spent-fuel pools. Irradiated fuel is curious material. When inside the core of an operating reactor irradiated fuel is so hazardous that the plant has an array of emergency systems whose sole purpose is to protect the fuel from damage by overheating.

Some of these emergency systems feature motor-driven pumps, while some feature stream-driven pumps. These emergency core cooling systems can be powered by the electrical grid, by the emergency diesel generators and in some cases by onsite batteries. The diversity and redundancy of these emergency core cooling systems provides high, but not absolute, assurance that the irradiated fuel will be adequately cooled. If the highly reliable emergency core cooling systems fail, the irradiated fuel in the reactor core is encased within strong concrete walls, 4- to 5-feet thick. This structure provides additional assurance that the public is protected.

After being discharged from the reactor core the irradiated fuel awaits transfer to a Federal repository which does not exist. The United States has spent more than $10 million—$10 billion on a proposed repository at Yucca Mountain in Nevada. DOE faces an immense engineering challenge siting a repository because that location must isolate the irradiated fuel from the environment for at least 10,000 years into the future or merely 42 times longer than we have been in the United States of America.

Between these two dangerous endpoints irradiated fuel sits in temporary spent-fuel pools with almost no protection. For unfathomable reasons, irradiated fuel is considered benign after it is taken out of the reactor, but before it is placed in a repository. Today tens of thousands of irradiated fuel sits in spent-fuel pools across America. At many sites near—there is nearly 10 times as much irradiated fuel in a spent-fuel pool as in reactor core. These pools are not cooled by an array of highly reliable emergency systems, not powered by the grid, diesel generators or batteries. Instead the pools are cooled by one regular system, sometimes backed up by one alternate make up system.

The spent-fuel pools are not housed within robust concrete containment structures designed to protect the public from the radioactivity they contain. Instead the pools are often housed in buildings with sheet metal siding like that in a Sears storage shed. I have nothing against the quality of Sears storage sheds, but they are not suitable for nuclear waste storage.

The irrefutable bottom line is that we have utterly failed to proper manage the risk from irradiated fuel stored at our Nation's nuclear power plants. We can and must do better.

There are two readily available measures to better manage that risk. First, accelerate the transfer of spent fuel from the pools to dry cask storage. And second upgrade the emergency procedures for spent-fuel pool accidents. Currently, we fill the pools to capacity and put the overflow into dry cask. This keeps the pools nearly filled with irradiated fuel, maintaining the risk about as high as you can achieve. A better strategy would be to reduce the inventory of irradiated fuel stored in spent-fuel pools, to only that amount discharged from the reactor in the last 5 or 6 years.

Less irradiated fuels in the pools results in a lower heat load in the pools, the lower heat load gives workers more time to recover cooling or re-establish the water inventory reducing the likelihood of fuel damage. And if fuel is damaged, for whatever reason, having less of it in the pools means the radioactive cloud emitted from that pool is much, much smaller, posing much less harm to people down wind.

Following the 1979 accident at Three Mile Island, the reactor owner significantly upgraded emergency procedures. Prior to that accident the procedures and training relied on the operators diagnosing what had happened and taking steps to mitigate that accident. If the miss—if the operators misdiagnosed the accident, those procedures could actually direct them to take the wrong steps for the accident they actually faced. The revamped Emergency Procedures Guide, the operators response to abnormally high pressure or an unusual low water level, without undue regard for what caused those abnormal conditions, this—these upgraded emergency procedures and training are significant improvements over the pre-TMI days.

But, no comparable procedures and training would help the operators respond to spent-fuel pool accidents. It is imperative that comparable emergency procedures be provided for spent-fuel pool accidents to derive the same safety benefits that we derive from improved procedures for reactor core accidents.

Thank you.

Senator FEINSTEIN. Thank you very much.

Gentlemen, I'm certainly not a nuclear expert, you are far more so. The first time I'd been in a nuclear plant was this past week. I visited the two in California, and spent the whole day doing it. What jumps right out at you is the difference between the containment of the core, the location of that spent-fuel pool and the dry cask situation.

Here's the question. There is a major study, apparently, by Bob Alvarez at the Nuclear Policy Institute for Policy Studies on the use of dry cask storage at nuclear power plants. He contends that dry cask has the potential to reduce the overall risk associated with reactor storage of spent fuel. So let me ask each of you, from your viewpoint, why does industry practice appear to be to keep the spent fuel in pool much longer than the required 5 to 7 years? Why wouldn't they move it aggressively to dry cask?

Dr. Moniz.

Dr. MONIZ. Thank you, Madam Chairman. First, I think at a very high level what I would say is that from the history of our nuclear power program I would say the storage, storage of spent fuel, between if you like the reactor and the presumed repository has been an afterthought. It has not really been part of our serious policy discussion about fuel cycle design. As a result, I think what one sees are in some sense, what may be very logical to a plant operator, operational decisions. So as David said, the dry cask storage is viewed more as the overflow when the pool can't handle any more densification. So I think what we need to do is to stand back, really ask what is our whole integrated system about storage and disposal. And that is exactly what I would call for. In fact, I think the move to dry cask is essential, furthermore for a set of reasons, I believe we should really start thinking hard about consolidated storage, presumably at Federal reservations to solve a host of problems.

Senator FEINSTEIN. Thank you. I agree with you.

Mr. Levis.

Mr. LEVIS. Thank you, Madam Chairman. And certainly the topic of used fuel and how we should dispose of it is I think one worthy of significant discussion. And I would not characterize the industry having a reluctance of putting used fuel bundles into cask storage; I would say one of the impactable items is really a lack of a national strategy and policy on what we are going to do with it.

And if I could just offer one thought in that particular area, we want to limit the number of times we have to handle used fuel and so we want to be able to take it out of the pool once, put it into cask and have it be able to go where it can go. Not all casks are designed for transportation, for example. So if in fact our policy is going to be to store it onsite there for a long period of time, we want to make sure we have casks that can do that. If our policy is to put it in a cask that can be transported, we want to make sure it can be in a cask that can do that.

So, you know, we were essentially planning for what we believe the direction of the country was headed. And it is not a reluctance to do this; we know how to do it. I would ask, if we want to speed that process up, that we consider things like supply chain availability and these sorts of things and making sure we have the, you know, the training and qualification for the people that need, you know, to do this sort of activity. But, I wouldn't characterize it as reluctance, you know, on our part to do it, but rather lacking what the national plan is and how we can develop our plan to match up with that.

Senator FEINSTEIN. Are you saying you believe, as an operator, we would be better off with a Federal policy that essentially set the handling of waste?

That we should have either regional repositories or a national repository?

Mr. LEVIS. Yes, what I was referring to, Madam Chairman, is what is the ultimate disposition of the used fuel, where will it go and what the most efficient way to get it there is.

Senator FEINSTEIN. Thank you.

Mr. Lochbaum.

Mr. LOCHBAUM. I would agree with the point that spent-fuel storage onsite was an afterthought. And I as think I agree with the industry position that it has been a shifting thought. The Federal Government keeps saying that we will take spent fuel on such and such a date and then that date slips by quite a bit. So it is difficult to base a decision on how best to store spent fuel onsite when the parameters keep shifting year to year. So I think I agree with Bill Levis that it has not been reluctance, it has been that shifting paradigm that keeps causing problems.

Senator FEINSTEIN. Dr. Moniz.

Dr. MONIZ. May I just add a point, because again I totally agree with Bill. It is again, it is the absence of a system that allows rational decisions. As Bill mentioned something that is very important, we don't have a consistent policy on these—literally just on things of sizes of casks, which is quite important.

But, if I may go back, you invited comments on the earlier panel, just to comment on the issue of the 100-year storage which Chairman Jaczko mentioned.

We think that there is a good case to be made for the integrity of 100-year storage, but the reality is it is based on extraordinarily skimpy database. And this is an example of the kind of R&D priority that we should have been having and I think now is being revived, pre-Fukushima, now it will be even more important.

And this gets to Bill's point about handling the fuel. While it may be that the fuel can be contained for 100 years, say in dry cask storage, but what about when you move it then? Will movement compromise integrity? These are the kinds of issues we need to have a system view of. And, I would say this is one of the many reasons why I personally favor consolidated storage, because if you bring this fuel together and there aren't any issues you can have, at that site, the infrastructure to deal with those problems and the spent fuel, if there are any after 80, 90, or 100 years.

Senator FEINSTEIN. Thank you. Senator Alexander.

Senator ALEXANDER. Dr. Moniz, if the Nation can't agree on a single repository, what makes you think it can agree on more than one for consolidated sites?

Dr. MONIZ. Thank you, Senator Alexander. First of all, I want to stress that the consolidated storage sites I am talking about are not necessarily repositories.

Senator ALEXANDER. Well, but they are places where you would haul the spent fuel for storage.

Dr. MONIZ. That is correct, so——

Senator ALEXANDER. So you would have the same issues of local support, wouldn't you?

Dr. MONIZ. Certainly and by the way, and I strongly support the idea that we should—we have to find public support in regions to move things. Now, I think having a dry cask storage facility is different from a repository. I don't claim it is easy; I am not Pollyannaish about it. It is tough.

Senator ALEXANDER. Yes, I know.

Dr. MONIZ. But also, I just inferred, for example, such a location would have, for example, a substantial research and testing infrastructure——

Senator ALEXANDER. Yes.

Dr. MONIZ [continuing]. Around the spent fuel, that is the kind of design that we need, I believe.

Senator ALEXANDER. Yes. Would you agree that Dr. Chu's plan and the attitude of others is that we could safely store our used nuclear fuel onsite, while for the next 10 or 20 years we develop aggressive R&D to try and find a better way to use and recycle nuclear fuel? Do you think that is both wise and safe to do?

Dr. MONIZ. Yes, sir. First, I would say that we don't see any large differentiator, technically, on safety or security or costs of distributed storage versus centralized storage. There are other system reasons why I prefer the centralized storage. Now——

Senator ALEXANDER. But what my question really is, while we do the R&D to get to that point——

Dr. MONIZ. Yes, now on the——

Senator ALEXANDER [continuing]. Is it safe to store it onsite?

Dr. MONIZ. Yes, it is. And now on terms of the R&D program, in our report last year we put forward exactly that kind of a program. And I should add, it is based upon something that Secretary Lyons inferred, that we do not believe that current reprocessing approaches, frankly, have merit, but we need to develop, possibly, more-advanced approaches.

Senator ALEXANDER. I want to ask you two more questions. The first is about radiation. We see on television news that trace amounts of radiation have been discovered in the United States as the result of the Japanese accident, yet testimony in the previous panel was we shouldn't worry about that. Why is that true?

Dr. MONIZ. Well, I will give a brief answer; maybe David will have more specifics on it. The information I have received is that the measurements in this country, including in my home State, are orders of magnitude below what are considered to be levels of concern.

Senator ALEXANDER. Well, is it true that every day we receive some radiation naturally from——

Dr. MONIZ. Yes, sir. In the United States the average citizen received about 300 millirem per year, which is let's say one-half of a CAT scan.

Senator ALEXANDER. And maybe another 300 from other——

Dr. MONIZ. Yes, and——

Senator ALEXANDER [continuing]. From CAT scans and——

Dr. MONIZ. On average, yes.

Senator ALEXANDER. And that it poses no harm for a person to receive 500 millirems——

Dr. MONIZ. Well, that is getting into an area which I am certainly not an expert. There is a lot of argument going on about so-called linear hypotheses and collective doses to the public. But my view is that it seems to be essentially no harm.

Senator ALEXANDER. Let me conclude with a question that you are an expert on. You mentioned the work that MIT and Oak Ridge are doing in modeling nuclear power plants. As I understand it, that is based upon the supercomputing capacity there and the R&D capacity there that this subcommittee and this Congress and this President are asked to fund on an annual basis. How important is the United States' ability to be among the leaders in the world in supercomputing to such programs as you are working on today to help us understand how to keep nuclear power plants safe?

Dr. MONIZ. A large-scale modeling and simulation applied to complex engineered systems is something the DOE, first of all, has been a leader in for a long time. It is something the country really should lead for very important, I believe, impacts on our manufacturing capability, our regulatory capability, those are the things that we are trying to do with this initial hub focused on LWR simulation.

Senator ALEXANDER. Thank you, Madam Chair.

Senator FEINSTEIN. Thank you very much.

You heard me ask the chairman about the option of an independent assessment of nuclear safety in our country. Say the National Academy of Science put together an assessment in light of what has happened at Daiichi and Daini and compared pressured water versus boiling water reactors, spent-fuel pools stored at reactor sites right now forever, because there is no other plan, and some in dry casks. Do you believe such an assessment would be a good idea?

Let me begin with you Mr. Lochbaum, what do you think of that idea?

Mr. LOCHBAUM. Well, an independent assessment is never a bad thing, but I think equally important or more important would be— the NRC is going to undertake the 90-day review and then a longer-term review. And they are going to come up with a lot of lessons learned that will be informed by what the work the IAEA is doing and the work that the industry is doing and the work that the independent assessment would do. I think it is vitally important for the Senate or the Congress more broadly, to look at the results from the NRC's review, what they have identified and their schedule for implementing that.

If they need more budget in order to make some of those things happen on a timelier basis that needs to happen. Because the best plan in the world doesn't really help anybody until it is implemented. So I think the NRC will come up with a good list of things to do to make our plants less vulnerable to that kind of thing and it is important that they get to the end of that effort as quickly as possible. So I think the Congress can help the NRC set its priorities and get there as expeditiously as possible.

Senator FEINSTEIN. Thank you.

Mr. Levis.

Mr. LEVIS. Madam Chairman, the industry will be looking at their own assessment of this event, you know, coordinated through INPO in concert with the World Association of Nuclear Operators and obviously the NRC will do its review independently. You know, we are committed to the absolute safety of our plants, we welcome any and all assessments and certainly an independent assessment would be fine, just to make sure we got it right.

Senator FEINSTEIN. Thank you. Thank you.

Dr. Moniz.

Dr. MONIZ. I would agree. I think it is—it would be unrealistic to think that we could move forward, frankly, without some kind of major assessment and I believe an independent assessment will be called for. What that means exactly, independent and who would be the independent body, is not entirely clear, in my view.

Senator FEINSTEIN. Well, would the National Academy of Science (NAS) be able to put that kind of body together, which is what they generally do when they look at something.

Dr. MONIZ. Yes, I think the NAS is certainly an option. Sometimes they move more slowly than one would like, but I think if they—in my view perhaps with a strong connection to an outstanding technical group, like INPO for example, could be a good way of putting together a review.

Senator FEINSTEIN. Thank you, anything else, Senator Alexander.

Senator ALEXANDER. No. I'd like to thank the witnesses for very helpful statements that you made and thank the chairman for looking into this. As I said at the beginning, it is very important that we talk about nuclear power. You know, nuclear power is such a complex mechanical operation that it makes sensational television news whenever there is a problem. Even though hundreds of thousands of people in Japan are homeless and a thousand bodies washed up on a beach one day, the news most days was about what was happening at the nuclear reactors.

And I think it is important that as a country we simply learn how to honestly ask questions and continuously improve what we are doing. At the same time, lots of people die every year from the pollution from coal plants that isn't collected in pollution control systems and from other forms of energy production. So I think it is important that we keep this all in perspective and we recognize that the safety record for the generation of nuclear power in the United States really couldn't be better, in terms of harm to people. It can always be improved. There are important lessons from Three Mile Island, but I have not heard anyone yet contradict my statement that no one was injured at Three Mile Island.

So this is helpful testimony and I think, Madam Chairman, the most important thing we can do is advance the research on used nuclear fuel, on SMRs, on any other safety enhancements that might be recommended that would continue to help us produce large amounts of reliable, low-cost, clean electricity of which I think nuclear power is an important component.

Senator FEINSTEIN. Well, thank you, Senator.

Of course, I come from a State that is in the ring of fire. The ring of fire has had some very big earthquakes around it. One of the things I learned from the USGS was that a section of the sea bottom, as large as the State of Maryland, moved in a subduction under the plate and that was what launched the tsunami which was just amazing for me to hear. I think no one ever thought, in the design process, that that kind of thing would happen.

Let me ask, do each of you have a last thought for us? Anything you would like to say and then we will conclude rapidly.

Mr. Levis.

Mr. LEVIS. I think the point that you make about what is it that we don't know is obviously something we challenge ourselves with every day, which is really the reason why these—some of these procedures that we refer to as severe accident management guides were developed, you know, a little over a decade ago, so that we could respond, you know, to the consequence of the event, versus trying to figure out what the event is. That means if the heat sink is lost, what would you do? If you lost emergency AC power what would you do?

So you know, we think—we ask ourselves continually those what if questions and what have we missed here. And I am sure there will be some significant learning out of here that we can apply to our plant designs and operating practices so we can improve the safety of our facilities.

Senator FEINSTEIN. Thank you. Thank you. I was with the CEO of Southern California Edison and he said the same thing you did that what we know is what we know and we have to challenge people with what we don't know. I very much agree with that. Dr. Moniz or Mr. Lochbaum.

Mr. LOCHBAUM. I would just say as the—obviously the event in Japan was tragic. Even if there were no lives lost from the radiation that has been released from the damaged cores, that was a multi-billion asset that became a multi-billion liability very quickly. So we need to, both for the economic cost of that accident, but also any human cost, we need to learn as much as we have. If the industry is going to do it, the NRC is going to do it and we—as tragic as the accident will be, it would be shame on us if we don't reap the full benefits of lessons learned from that.

Senator FEINSTEIN. Thank you. Dr. Moniz.

Dr. MONIZ. Thank you, Madam Chairman.

Perhaps I could make a few comments about R&D programs, that is obviously something under the direct purview of this subcommittee and you will be considered it. Just a note, that again last year we issued a report on the future of the nuclear fuel cycle. I just wanted to note some of the areas that we noted for R&D, viewing these as real gaps, historically, in the program.

Life extension for LWRs and technologies, some new technologies like fuel, cladding which we mentioned earlier, for safety margins, advanced fuel development for a LWR. The modeling and simulation is part of the way of verifying and quantifying uncertainties—dry cask storage life extension—other concepts include enhanced waste forms for storage and disposal. What I emphasize is that this is way before Fukushima, this was last year, that these kinds of technologies which are about the work horse of our nuclear fleet, LWRs, has been neglected and I believe this should be a very strong priority for R&D.

We did have, in addition to this, something that Senator Alexander referred to, which was also a program for the future possible closed fuel cycles that might make sense for reasons of waste management or resource extension. But our view as the number one priority, strategic view is if nuclear power is to play an important role in the next few decades it is these things we need: the storage technologies, the new fuels, the new cladding with better safety margins, et cetera. So I would urge, in your consideration of the DOE budget, that these be given a lot of attention. Thank you.

Senator FEINSTEIN. You make a lot of sense. Senator Alexander.

Senator ALEXANDER. Madam Chair, may I ask permission to include in the record an article from The Guardian of London on Sunday by one of the leading environmentalists in the country which is headlined, "Why Fukushima Made Me Stop Worrying and Love Nuclear Power". His comment was, "Atomic energy has just been subjected to one of the harshest possible tests and the impact on people and the planet has been small. The crisis at Fukushima has converted me to the cause of nuclear power."

Senator ALEXANDER. This is——

Senator FEINSTEIN. Oh my goodness.

Senator ALEXANDER. Well, the——

Senator FEINSTEIN. The effect has been small?

Senator ALEXANDER. Of the reactors.

Senator FEINSTEIN. On the reactor.

Senator ALEXANDER. Of the——

Senator FEINSTEIN. But the affect on the country, on the people, on the economy, on the sea bed is enormous.

Senator ALEXANDER. The effect of the reactors. These are his comments. But he reviews, in his article, that the disaster would weigh more heavily, he said, if there were less harmful alternatives. He goes through all the other ways of producing energy and concludes atomic power has to be part of the mix.

And in any event, this is just one person who is an environmentalist who had that unusual reaction to the disaster.

Senator FEINSTEIN. Thank you, we will put it in the record.

[The information follows:]

[From the guardian.co.uk, March 21, 2011]

WHY FUKUSHIMA MADE ME STOP WORRYING AND LOVE NUCLEAR POWER

(By George Monbiot)

You will not be surprised to hear that the events in Japan have changed my view of nuclear power. You will be surprised to hear how they have changed it. As a result of the disaster at Fukushima, I am no longer nuclear-neutral. I now support the technology.

A crappy old plant with inadequate safety features was hit by a monster earthquake and a vast tsunami. The electricity supply failed, knocking out the cooling system. The reactors began to explode and melt down. The disaster exposed a familiar legacy of poor design and corner-cutting. Yet, as far as we know, no one has yet received a lethal dose of radiation.

Some greens have wildly exaggerated the dangers of radioactive pollution. For a clearer view, look at the graphic published by xkcd.com. It shows that the average total dose from the Three Mile Island disaster for someone living within 10 miles of the plant was 1⁄625 of the maximum yearly amount permitted for U.S. radiation workers. This, in turn, is half of the lowest 1-year dose clearly linked to an increased cancer risk, which, in its turn, is 1⁄80 of an invariably fatal exposure. I'm not proposing complacency here. I am proposing perspective.

If other forms of energy production caused no damage, these impacts would weigh more heavily. But energy is like medicine: if there are no side-effects, the chances are that it doesn't work.

Like most greens, I favour a major expansion of renewables. I can also sympathise with the complaints of their opponents. It's not just the onshore windfarms that bother people, but also the new grid connections (pylons and power lines). As the proportion of renewable electricity on the grid rises, more pumped storage will be needed to keep the lights on. That means reservoirs on mountains: they aren't popular, either.

The impacts and costs of renewables rise with the proportion of power they supply, as the need for storage and redundancy increases. It may well be the case (I have yet to see a comparative study) that up to a certain grid penetration—50 percent or 70 percent, perhaps—renewables have smaller carbon impacts than nuclear, while beyond that point, nuclear has smaller impacts than renewables.

Like others, I have called for renewable power to be used both to replace the electricity produced by fossil fuel and to expand the total supply, displacing the oil used for transport and the gas used for heating fuel. Are we also to demand that it replaces current nuclear capacity? The more work we expect renewables to do, the greater the impact on the landscape will be, and the tougher the task of public persuasion.

But expanding the grid to connect people and industry to rich, distant sources of ambient energy is also rejected by most of the greens who complained about the blog post I wrote last week in which I argued that nuclear remains safer than coal. What they want, they tell me, is something quite different: we should power down and produce our energy locally. Some have even called for the abandonment of the grid. Their bucolic vision sounds lovely, until you read the small print.

At high latitudes like ours, most small-scale ambient power production is a dead loss. Generating solar power in the UK involves a spectacular waste of scarce resources. It's hopelessly inefficient and poorly matched to the pattern of demand. Wind power in populated areas is largely worthless. This is partly because we have built our settlements in sheltered places; partly because turbulence caused by the buildings interferes with the airflow and chews up the mechanism. Micro-hydropower might work for a farmhouse in Wales, but it's not much use in Birmingham.

And how do we drive our textile mills, brick kilns, blast furnaces and electric railways—not to mention advanced industrial processes? Rooftop solar panels? The moment you consider the demands of the whole economy is the moment at which you fall out of love with local energy production. A national (or, better still, international) grid is the essential prerequisite for a largely renewable energy supply.

Some greens go even further: why waste renewable resources by turning them into electricity? Why not use them to provide energy directly? To answer this question, look at what happened in Britain before the industrial revolution.

The damming and weiring of British rivers for watermills was small-scale, renewable, picturesque and devastating. By blocking the rivers and silting up the spawning beds, they helped bring to an end the gigantic runs of migratory fish that were once among our great natural spectacles and which fed much of Britain—wiping out sturgeon, lampreys and shad, as well as most sea trout and salmon.

Traction was intimately linked with starvation. The more land that was set aside for feeding draft animals for industry and transport, the less was available for feeding humans. It was the 17th-century equivalent of today's biofuels crisis. The same applied to heating fuel. As EA Wrigley points out in his book *Energy and the English Industrial Revolution,* the 11m tonnes of coal mined in England in 1800 produced as much energy as 11m acres of woodland (one-third of the land surface) would have generated.

Before coal became widely available, wood was used not just for heating homes, but also for industrial processes: if half the land surface of Britain had been covered with woodland, Wrigley shows, we could have made 1.25m tonnes of bar iron a year (a fraction of current consumption) and nothing else. Even with a much lower population than today's, manufactured goods in the land-based economy were the preserve of the elite. Deep green energy production—decentralized, based on the products of the land—is far more damaging to humanity than nuclear meltdown.

But the energy source to which most economies will revert if they shut down their nuclear plants is not wood, water, wind or sun, but fossil fuel. On every measure (climate change, mining impact, local pollution, industrial injury and death, even radioactive discharges) coal is 100 times worse than nuclear power. Thanks to the expansion of shale gas production, the impacts of natural gas are catching up fast.

Yes, I still loathe the liars who run the nuclear industry. Yes, I would prefer to see the entire sector shut down, if there were harmless alternatives. But there are no ideal solutions. Every energy technology carries a cost; so does the absence of energy technologies. Atomic energy has just been subjected to one of the harshest of possible tests, and the impact on people and the planet has been small. The crisis at Fukushima has converted me to the cause of nuclear power.

Senator FEINSTEIN. It is unusual.

Your thoughts have been very helpful. I would just ask that if you have other thoughts, please communicate them to this subcommittee because Dr. Moniz is right, this R&D program is directly under our jurisdiction and we certainly need to consider the things that you mentioned and we will.

ADDITIONAL COMMITTEE QUESTIONS

At this time I would like to ask the members of the subcommittee to please submit any questions they have for the witnesses for inclusion in the record.

[The following questions were not asked at the hearing, but were submitted to the Department for response subsequent to the hearing:]

QUESTIONS SUBMITTED TO DR. PETER B. LYONS

QUESTIONS SUBMITTED BY SENATOR MARY L. LANDRIEU

Question. Can you please explain what a passive reactor is and why it is or is not considered safer than the boiling water or pressurized water reactors? For instance, it is my understanding that high-temperature, gas-cooled reactors (HTGRs) that are currently being developed under the Department of Energy's (DOE) Next Generation Nuclear Plant Program have natural safety features that ensure any significant radiation could never be released to the public no matter how serious the accident. Is this true and would you please describe why these reactors are so safe? In addition, what is DOE doing to promote the use of technology that utilizes a passive reactor?

Answer. The current fleet of reactors utilizes engineered safety features characterized by redundant and diverse systems to deliver cooling water to the reactor core and remove heat from the primary containment. The new light water reactor (LWR) designs, including small modular reactors, are even safer than the current fleet of reactors since they make use of passive safety features that rely on natural forces (such as gravity and natural circulation) rather than engineered safety features and emergency power supplies. HTGRs move beyond these passive safety features by incorporating additional inherent physical characteristics that enhance safety. These features include the use of advanced, coated particle fuel that retains the nuclear fission product materials during all design basis and severe accidents. HTGR-coated particle fuel operates at lower power densities (approximately 6 watts per cubic centimeter) than typical LWR fuel (60–100 watts per cubic centimeter) so that there is a reduced probability of core fuel damage and radioactive fission product releases. During severe accidents the HTGR reactor can be cooled passively without the use of active heat transfer systems that rely on electrical power, operator actions, or any active control systems. Some engineers have referred to these plants as being inherently safe.

Question. What has and will the NRC do to ensure that our U.S. reactors are safe and are prepared for the worst case scenario?

Answer. The NRC's efforts to assure safety of commercial nuclear reactors begin with the licensing process. Each operating reactor in the United States underwent a rigorous design review before receiving a license. The applicants had to satisfy NRC safety requirements to assure that the design of the reactors and the associated emergency equipment, such as emergency cooling water pumps, would safely respond to a variety of adverse events.

The NRC also licenses the reactor operators who provide the immediate response to any plant event. There are significant training and testing requirements for the operators, which include demonstrating knowledge of the appropriate response to accidents. In addition, the emergency planning requirements for power reactors are based on a spectrum of accidents, including severe accidents.

On a day-to-day basis, inspections are done by onsite "resident" inspectors and visiting inspectors from the NRC's four regional offices and the NRC's headquarters. These inspections are part of the NRC's "Reactor Oversight Process" and assess how the reactor and utility staff perform in areas such as maintenance, engineering, operations, security, radiation protection, and emergency planning. Through the inspections, the NRC determines whether the licensee is operating in accordance with its license and that the plant systems will be capable of performing their safety functions in response to an event.

Following recent events in Japan, the NRC established a senior level task force to conduct a methodical and systematic review of NRC processes and regulations to determine whether the agency should make additional improvements to our regulatory system and make recommendations to the NRC for its policy direction. This task force will also identify a framework and topics for a longer-term review and assessment.

In addition, NRC inspectors are assessing licensee activities and actions concerning readiness to respond to an event similar to the Fukushima Daiichi nuclear plant incident. To direct the inspections, the NRC issued a Temporary Instruction (TI) on March 23, 2011 to its inspectors. Using this guidance, the NRC's inspectors assessed the licensee's capability to mitigate conditions that result from "beyond design basis" events typically bounded by security threats, loss of all onsite electricity (i.e. "station blackout"), and flooding events. On May 13, 2011, the NRC began issuing reports to the Nation's 104 operating nuclear power plants regarding inspections of the plants' abilities to deal with power losses or damage to large areas of a reactor site following extreme events. Our inspectors found all the reactors would be kept safe even in the event their regular safety systems were affected by these events, although a few plants have to do a better job maintaining the necessary resources and procedures.

U.S. commercial nuclear power reactors have Emergency Operating Procedures' (EOPs) to direct actions in response to events and plant conditions. In response to an industry initiative in the 1990s, the U.S. industry developed Severe Accident Management Guidelines" (SAMGs) to address situations beyond the EOPs. During the NRC's task force's deliberations thus far, the importance of SAMGs has been highlighted. Thus, the NRC issued on April 29, 2011, a new TI to confirm that the SAMGs are available and being maintained, and determine the nature and extent of licensee implementation of SAMG training.

Question. I know that 23 of the United States reactors are a General Electric Mark 1 design, the same design as at the Fukushima Daiichi facility in Japan. Yet, I believe each of these 23 facilities has been retrofitted and modified to address venting and other concerns with this reactor design. Can you please walk me through why the modifications were needed at the U.S. facilities? Can you confirm that all of these reactors have been modified? Does this make our reactors safer than the reactors in Japan?

Answer. In the 1980s, the NRC staff completed a determination of what actions should be taken to reduce the vulnerability of the original Mark I containments to severe accident challenges. This work is documented in NRC's Generic Letter 89–16. The Mark I containment has a light-bulb shaped "drywell" in which the reactor pressure vessel is located; below the drywell, there is a donut or torus-shaped "wetwell" partially filled with water (i.e., the "suppression pool"). There are pipes that connect the drywell to the suppression pool. If there is damage to the reactor pressure vessel or piping connected to it, the drywell will fill with steam and the resulting pressure will force the steam into the suppression pool. The water in the suppression pool will cool and condense the steam, thus reducing the pressure in the containment drywell and wetwell. Even before the installation of the hardened wetwell vents, the NRC staff recognized that under emergency conditions the plant's operators might vent the wetwell to avoid exceeding the maximum containment pressure limits. However, the previous methods of venting used nonpressure retaining pathways, and thus could have made vital areas of the plant inaccessible and potentially unsafe during and after venting. Therefore, the NRC directed the staff to pursue enhancements to the Mark I containments, and in particular to approve installation of a hardened wetwell vent for plants that elect to incorporate this improvement. For the remaining plants, the staff was directed to initiate plant-specific backfit analyses for each of the Mark I plants to evaluate the efficacy of requiring the installation of hardened wetwell vents.

Given a scenario of a long-term loss of decay heat removal, the staff found that use of reliable containment venting and procedures could reduce the chance of a core melt accident by a factor of 10, and that the vent would also reduce the likelihood of a core melt accident during other events like a station blackout. Hardened wetwell vents are designed to allow operators to prevent containment failure by controlled reduction of containment pressure during severe accidents. Venting from the wetwell allows for significant reduction in the release of radioactive airborne contamination by the scrubbing action of the suppression pool water. The vent was designed to discharge away from the secondary containment building, better supporting subsequent operator actions there. The vent capability was also designed to allow release of combustible gas (hydrogen resulting from the reaction of fuel cladding with coolant at elevated temperatures) to prevent containment failure.

No NRC orders were issued for installing a hardened wetwell vent, and all modifications made were voluntary. Licensees were allowed to justify not installing the hard pipe vent based on plant unique configuration and circumstances. All 23 BWR Mark I plants either installed the modification described in the generic letter (22 plants), or justified use of existing plant safety features (1 plant). Installation of the vent was designed to improve safety of the plants in the United States.

Other improvements in these containment and safety systems were also studied and implemented from the late 1970s through the 1990s, including the strengthening of the wetwell, inerting of containment during operations to prevent hydrogen explosions in the case of a core damage accident, and installing larger suction strainers for emergency cooling pumps.

The NRC does not currently have sufficient information about how venting was, or was not, accomplished in Japan, thus we cannot yet provide a comparison between the United States approach to venting and the Japanese approach.

Question. I am told that in the upcoming year, 2 of the 5 NRC Commissioners will be up for replacement. Given the events that have taken place over the past month, and the number of U.S. nuclear facilities that will need renewal licenses, can you please speak to the importance of having a full panel as the NRC moves forward to tackle these issues?

Answer. Commissioner Ostendorff's current term will end on June 30, 2011. He has been re-nominated by the President for a full-term; that nomination is currently with the Senate Environment and Public Works Committee for consideration. Because Commissioner's terms are staggered, the next term to end is Commissioner Svinicki's at the end of June 2012. The NRC is designed to be a collegial body of five responsible for policy formulation, rulemaking, adjudications, and adjudicatory orders. The diversity of experience, knowledge, and opinions among the Commissioners strengthens the formulation of agency policy and the execution of our critical mission.

CONCLUSION OF HEARING

Senator FEINSTEIN. So thank you gentlemen, very much, for the testimony. It is very helpful. And the hearing is recessed.

[Whereupon, at 11:55 a.m., Wednesday, March 30, the hearing was concluded, and the subcommittee was recessed, to reconvene subject to the call of the Chair.]

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