BLUE RIBBON COMMISSION ON AMERICA'S NUCLEAR FUTURE

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REACTOR AND FUEL CYCLE TECHNOLOGY SUBCOMMITTEE

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MEETING

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DAY 1

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MONDAY,

AUGUST 30, 2010

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The Subcommittee convened, at 8:00 a.m., in Ballrooms D and E of the Washington Marriott, 1221 22nd Street, Northwest, Washington, DC, Pete Domenici and Per

Peterson, Co-Chairs, presiding.

MEMBERS PRESENT:

PETE V. DOMENICI, Chair
PER PETERSON, Chair
ALBERT CARNESALE

SUSAN EISENHOWER
ALLISON MacFARLANE
RICHARD A. MESERVE
BRENT SCOWCROFT
PHIL SHARP

ALSO PRESENT:

TIM FRAZIER, Designated Federal Official

ALAN HANSON, AREVA

JACK FULLER, General Electric Hitachi Nuclear Energy

KATE JACKSON, Westinghouse

ALAN DOBSON, Energy Solutions

JOHN PARMENTOLA, General Atomics

PAUL LORENZINI, NuScale

CHRISTOPHER MOWRY, Babcock and Wilcox

ROBERT HARGRAVES, Institute for Lifelong Education at Dartmouth

THOMAS COCHRAN, Natural Resources Defense Council

GEOFFREY ROTHWELL, Stanford University

REBECCA SMITH-KEVERN, US Department of Energy

MIKE CAZAUBON, NuStart Energy

JOHN KELLY, American Nuclear Society

RAY ROTHROCK, Venrock Capital

JAMES ASSELSTINE, Barclays Capital

JACK SPENCER, Heritage Foundation

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

8:01 a.m.

MR. FRAZIER: Okay. I would like to welcome you all to the Reactor and Fuel Cycle Technology Subcommittee of the Blue Ribbon Commission on America's Nuclear Future.

And without further ado, I'm going to turn it over to Per or Senator Domenici. Senator?

CHAIR DOMENICI: Thank you very much.

Welcome, everyone.

I'm Pete Domenici, Co-Chairman with Per Peterson.

We have a long session today, so we would appreciate it if everybody would follow rules that have been laid down and then circulated.

This is day one of a two-day hearing.

Can everybody hear what I'm saying? Got it? Okay? Not good? How about that? Is that better? Just a little? Well, somebody fix this. That's all I can do, I guess. It's better?

All right. Our first panel today is called "the Opportunities in Reactor and Fuel Cycle Technologies". Prior to their appearance today, the Commission asked the panelists to consider the following questions. Everyone should know that we asked to try to do this.

One, from your perspective, are there technology options, including alternatives to the once-through cycle, that hold significant potential to influence the way in which used fuel is stored and disposed?

Second, are there federal actions that could facilitate commercial efforts to develop and deploy these technology options while meeting economic, safety, environmental protection, security, and non-proliferation goals?

I would like to remind our invited

speakers that they are to keep their presentations to 10 minutes or less, and that the remainder of the panel's time will be spent on questions and discussions with the Subcommittee members.

Let me introduce our first panelist. All right, let me introduce our first panel. Dr. Alan Hanson, Executive Vice President of Technologies and Used Fuel Management from AREVA.

Our second panelist is Jack Fuller, Chairman of the Board for GE Hitachi Nuclear Energy.

Our next panelist is Dr. Kate Jackson, Chief Technology Officer for Westinghouse.

And our next panelist is Mr. Alan Dobson, Senior Vice President of Energy Solutions.

Following that will be Dr. Ed Lyman, Senior Scientist, the Union of Concerned Scientists.

And our last panelist is Dr. Marvin Resnikoff, Senior Associate of Radioactive Waste Management Associates.

Before we proceed with any of our panelists, my Co-Chairman, Dr. Per Peterson, has some remarks.

CHAIR PETERSON: Excellent. Thank you, Senator Domenici.

I look forward, also, to hearing from our speakers today. We are fortunate to have so much interest from a diverse and knowledgeable group.

We have invited everybody here to help us gain a broader understanding of the issues associated with continued utilization of reactor and fuel cycle technologies.

When looking at this meeting's agenda, it is important to note that our Reactor and Fuel Cycle Technology Subcommittee was formed to address the question, and this is a question: do technical alternatives to today's once-through fuel cycle offer sufficient promise to warrant serious consideration and R&D investment? And do these technologies hold significant potential to influence the way in which used fuel is stored and disposed?

While our first Subcommittee meeting in Idaho specifically focused on understanding major U.S. R&D programs, specifically R&D conducted by the Department of Energy's Office of Nuclear Energy and industry's Electric Power Research Institute, today and tomorrow's panels will begin to look at the major issues associated with commercialization, those issues that affect the potential to bring these new technologies into commercial deployment.

The United States is an undisputed leader in innovation and improvement in other highly-regulated technologies, such as commercial aircraft, drugs, and medical devices. This U.S. market dominance is not an accident. It comes from having well-designed federal policies that incentivize innovation and commercial investment, and having highly-competent and capable regulatory authorities.

While this specific meeting covers topics that relate to commercialization of new reactor and fuel cycle technologies, I would like to also note that subsequent meetings of our Subcommittee will cover additional areas, including economic valuation of costs and benefits of new reactor technologies; regulations for safety, health, and environmental protection, and nuclear non-proliferation and physical security of facilities and materials.

So, in closing, I would like to again thank all of our panelists today. We look forward to a productive two days for the Subcommittee meeting.

And now I would like to open the floor to any of our other Commissioners who would like to make a brief statement.

Any at this point?

(No response.)

Okay. Then I think that we can begin the day's activities.

And, Senator, I think that you are the one who will introduce the first panelist.

CHAIR DOMENICI: Our first panelist is Dr. Alan Hanson, Executive Vice President of Technologies and Used Fuel Management at AREVA.

Please proceed.

DR. HANSON: Thank you, Mr. Chairman. It's a pleasure to be here this morning.

The Commission's invitation requested information in two broad areas. The first one is technology options, alternatives to the once-through cycle, and the second one is federal actions that would facilitate commercial efforts to develop such technologies. I am going to try briefly to discuss both of those. More details can be found in my written testimony, which was submitted earlier.

AREVA supports an integrated approach to used fuel management in the United States that includes interim storage, recycling, and disposal. Commercial recycling of used nuclear fuel has a long and successful, safe, and secure history, albeit mostly outside of the United States. AREVA has successfully and profitably operated a recycling complex for more than four decades.

So, let me begin by discussing a recycling technology option using aqueous processing and recycling thermal reactors. Today there's approximately 60,000 tons of so-called nuclear waste sitting in pools in dry storage in the United States. This is not waste. This is used fuel, and it is largely recyclable.

When it's discharged from the reactor, it is not completely spent. Recycling consists of separating the waste material from the reusable material, the uranium and plutonium, and manufacturing fresh, new fuel.

In terms of mass, 96 percent of the content of the used fuel is reusable. The remaining 4 percent is the actual high-level waste which contains practically no remaining fissile material and no energy value.

Recovered uranium can be re-enriched and used to fabricate fresh, new fuel assemblies. Recovered plutonium is blended with depleted uranium to produce mixed oxide fuel and put back in commercial reactors.

The remaining 4 percent of waste is stabilized in a vitrified form for geologic disposal.

This process, invented in the United States, has benefitted from decades of lessons learned and continuous improvements in other places in the world, particularly in France, the UK, and Japan.

But rather than employ state-of-the-art technologies and processes, an approach that we would recommend would do the following:

It would implement an enhanced co-extraction process which produces no pure plutonium either as the end product or anywhere in the plant.

Co-location of treatment and fuel fabrication facilities, enhanced protection systems and design approaches, and flexibility in design, so that advanced separation techniques can be added later.

In short, what we are suggesting is not your father's PUREX reprocessing. It is advanced aqueous recycling.

Now I want to discuss some of the benefits associated with doing this.

First of all, it reduces the burden on the geologic repository. This, of course, is much of what the Commission is seeking to do. Only 4 percent, as I said, of the used fuel has to go into that geologic repository. And when it is vitrified into a highly-stable glass form, it is very suitable for disposal.

The volume reduction is crucial, as it allows maximum use of the geologic repository. We are heat-limited in some locations, and we need to minimize the heat as well. But reducing the volume and at the same reducing some of the isotopes helps in that regard as well.

Reducing radiotoxicity is another goal, and recycling does this. The main contributors to long-term toxicity are the uranium and plutonium, which are removed and recycled. The remaining fission products and some of the minor actinides will decay in a period of time that is less than it would be with the uranium/plutonium included.

I've already mentioned the robust waste form. The glass matrix that holds the fission products is highly stable and will last for hundreds of thousands, millions of years. This can be demonstrated through scientific analysis of the glass.

Recycling also contributes to energy security. The 60,000 tons of used fuel that is sitting in the United States is a resource which could, if all recycled, power all 104 reactors for six or seven years with no more uranium pulled out of the ground. I'm not suggesting that be done, but it gives you an indication of the magnitude of the energy resource.

And of course, it saves that resource because you don't need to dig out the virgin uranium and to enrich it. And as a result of that, you can reduce the amount of uranium needed by about 25 percent.

Recycling produces a waste form which is free of IAEA safeguards. You don't need to spend the rest of your life safeguarding the vitrified waste because it has no fissile content of any significance.

Now let me address proliferation because, of all the issues that seem to be an obstacle to recycling, this is the key one. I would argue that recycling supports an international non-proliferation framework.

Burning plutonium destroys approximately 30 percent of the plutonium in the used fuel and it degrades the composition of the rest of the fuel to such a level that it is less attractive for weapons purposes.

Don't misunderstand. This doesn't mean that it can't be done. The physics say that it can. But it is certainly less attractive.

So, we take our non-proliferation responsibilities very seriously, and we believe that recycling, in fact, contributes to non-proliferation.

The fundamental question before the Commission, would a decision by the U.S. to recycle used fuel and close the nuclear fuel cycling contribute to proliferation or it would do the opposite and contribute to a strong international non-proliferation paradigm?

The federal government has been successful in protecting its own stockpile of weapons-grade material. So there is no reason to believe that it cannot adequately protect less attractive reactor-grade materials from commercial recycling.

If diversion or theft of plutonium can be prevented by extensive national and international safeguards and physical protection, there's only one reason not to do it, and that is not to set an example for the rest of the world. This, of course, is the ostensible reason that we stopped recycling in the United States 30 years ago.

But that policy did not prevent Britain, France, Japan, or Russia from domestic recycling, and I'm here to tell you it will not stop China and India, who are moving ahead aggressively to do commercial recycling.

Notice that the only countries

that build recycling facilities are ones with very large programs, and that's necessary because the economics of recycling are such that you have to do it on a large scale to make it economically attractive.

For the United States to effectively lead in meeting the non-proliferation challenge internationally, a policy shift is going to be needed here at home.

Again, we propose an integrated used fuel management strategy that includes recycling, or at least at this point in time includes the option for recycling. This would help limit the continuing accumulation of used fuel, utilize the residual energy value, restore credibility in fuel cycle management, support the nuclear renaissance, and, importantly, establish an industrial skilled workforce to carry out recycling in the future.

Federal research and development

is still needed. I don't want to suggest that we know everything that we need to know about recycling. However, this is not the full answer to what needs to be done.

I would caution the Commission against trying to leapfrog technologies and to seek fuel cycles which don't exist. In particular, a proliferation-proof fuel cycle, no such thing exists, and we shouldn't be looking for it. We should try to improve proliferation resistance, and that can be and should be done with technologies that are available today. And today, the United States has got a pressing obligation to address our large and growing used fuel backlog.

There are important socioeconomic considerations that must be addressed.

CHAIR DOMENICI: Sir?

DR. HANSON: Yes?

CHAIR DOMENICI: Why do you caution us on that regard?

DR. HANSON: I could give you a

couple of examples which I will postpone until later of cases where the United States has tried to leapfrog technology and has produced less-than-desirable results, and in some states catastrophic results.

CHAIR DOMENICI: So you're saying it's just not a good way to go?

DR. HANSON: It's not a good way to go. The nuclear industry evolves in an evolutionary fashion, not a revolutionary fashion. I've got some good examples for you, if you want.

CHAIR DOMENICI: Okay. I got you. Thank you.

DR. HANSON: Okay. The cost of recycling needs to be quantified. I've seen numbers all over the map. We know very well at AREVA what it costs to do recycling. I'm not going to argue that it is more or less than throwing fuel away. I would just caution people here nobody has been successful in throwing fuel away directly and, therefore, we don't know what the cost is to do that. We do know what the cost of doing recycling is.

Other advantages:

Thousands of skilled labor jobs are created, and this would provide local economic development.

Private capital can be leveraged in order to do recycling under the proper circumstances.

And of course, extensive environmental monitoring is an imperative.

Now, in order to finish here, I want to turn to the second question regarding actions to facilitate recycling and better used fuel management. And there are a couple of things that I would highly recommend.

The current U.S. policy framework is from another era. The once-through fuel cycle is not consistent with the resurgence of nuclear power. More nuclear power means more used fuel, and something needs to be done to deal with it.

Policy modernization in the United States is crucial to restoring public confidence in nuclear energy. In order to do that, we must chart a path that enables an integrated used fuel management solution with options for interim storage, recycling, and disposal.

A national commitment is needed, a commitment that stays in place for a long time. And to assure public acceptance, U.S. policy should affirmatively support the recycling of used nuclear fuel.

Just to conclude, there are two things that we need. We need to remove the responsibility for waste from the Department of Energy and place it in an independent federal corporation, free from the vagaries of politics and the budget cycle.

And we need a stable regulatory environment at the NRC. To their credit, they have started down this path, and they should continue, so that we have the means to do recycling at some point in the near future.

Thank you very much. I'm sorry it was very rushed. I would be happy to answer questions later on, if you have them.

CHAIR DOMENICI: Thank you very much, sir. We're the ones that rushed you. We don't give you much time, but we'll read your statements; don't worry.

Our next witness is Dr. Jack Fuller, Chairman of the Board for GE Hitachi Nuclear Energy.

MR. FULLER: Thank you, Mr. Chairman.

Good morning.

I'm Jack Fuller, the Chairman of the GE Hitachi Nuclear Energy. I'm delighted to have the opportunity to be here today to share with you my vision for America's nuclear energy future and to specifically outline a policy direction that makes sense for the country.

As it has done for decades, the

U.S. nuclear industry has the potential to lead in innovation of the next-generation nuclear technologies, new technologies to enrich uranium, to generate, safe, clean, and reliable electricity, and to recycle nuclear fuel. However, as is the case in the nuclear industry, government policy is the key to success in this area.

GE Hitachi nuclear energy, a global alliance formed by GE and Hitachi, is prepared to offer new technologies to customers around the world. Headquartered in Wilmington, North Carolina, GEH is a world-class enterprise with a highly-skilled workforce and global infrastructure dedicated to serving the nuclear industry. We're proud of our record of accomplishments, both in the U.S. and overseas, that spans over five decades in the business.

Our nuclear alliance is recognized as the world's foremost developer of boiling water reactors, robust fuel cycle products, and highly-valued nuclear services.

For years now, we have been hearing about the next nuclear renaissance. I'm a little reluctant to use that term, but I do envision a future that has as many as 250 to 1,000 new plants by the year 2030 around the world, as estimated by the World Nuclear Association.

As we enter this new era, innovation will help bring solutions, solutions to life extension and power uprates for our current fleet of plants, developing the Generation-3 passive designs of ESBWR for future generations, enriching uranium more efficiently with laser technology, and addressing the most debated, although I would argue not the most difficult challenge of what to do with the used nuclear fuel.

We have been tempted in the U.S. to believe the solution to the back-end of the fuel cycle is too complex to solve. However, on a simple level, I think it's no more difficult than what we do at home, recycle and reuse materials. We can boil it down to the options of what I call the 3 R's: repository, reprocessing, and recycling.

And I want to differentiate my comments from my friend here from AREVA, that what I believe I will be talking today about is advanced recycling technology, not reprocessing technology, which uses MOX fuel that we currently do today with our friends at AREVA for our Japanese customers.

Certainly we can design a safe repository for long-term. We have proved that on used fuel. Or we can follow the policy choice of our allies to reprocess light water reactor used fuel.

However, we have another option, the next step in technology: recycling of our nuclear fuel using scientifically-proven technology. We believe it is time for the U.S. to embrace a policy of recycling of this fuel.

Full recycling takes used nuclear fuel and separates the uranium and the transuranics using a molten salt path and electricity. The recovered uranium and transuranics are then used as fuel in the Generation-4 technology reactor, thereby generating electricity from this used fuel. The remaining fission product wastes are placed in a ceramic and metal alloy, which requires safe storage in an acceptable repository going forward.

This process is preferred to other solutions for several reasons, including:

First, reducing the required storage time for the waste from thousands and thousands of years to 300 to 500 years.

Second, extracting greater than 90 percent of the available energy from the uranium ore as compared to 5 percent extracted with the current technologies.

Third, minimizing proliferation concerns by not separating plutonium from the other transuranics.

And finally, eliminating the government's need for support after we commercialize this technology.

Our vision is to have advanced recycling centers located near operating plants. As shown in this slide, the center would include two different buildings, one that houses modules that would do the separations, a second that houses a sodium-cooled reactor generating electricity and burning up the transuranic materials. By the way, this is what we call a small module reactor of about 300 megawatts per unit.

The capital cost of these two buildings is relatively low since, just like adding on capacity to your house as your family grows, you would add additional separation and generation capacity as your needs arise.

The economics of the recycling center improves as additional units are added, through replication of the design that you provided in the first one.

We believe that if a recycling policy is adopted, we could have a demonstration advanced recycling center operating in about 15 years, followed by multiple commercial units the following decades.

Some of the specific items that need to get to this vision are highlighted in my written statement, but let me quickly point out ones that need to be done now.

First and foremost, Congress needs to adopt the fed-corp legislation creating an organization that has the authority to establish and manage a long-term solution for the back-end of the fuel cycle.

Second, Congress should fund a small reactor R&D program that includes advanced reactors, such as PRISM and pyro processing, as well as small light water reactors.

And finally, by recommending full recycling, the Blue Ribbon Commission can help ensure U.S. technology leadership and enhanced energy security while at the same time address the policy challenge of nuclear fuel management in a very pragmatic way.

I want to thank you for the opportunity to be here today, and I look forward to further discussions on this topic. Thank you.

CHAIR DOMENICI: Thank you, sir.

Now we are going to proceed to our next witness, Dr. Kate Jackson, the Chief Technology Officer for Westinghouse.

We're delighted to have you, and we're sorry that we are only giving you such a short period of time.

DR. JACKSON: That's okay, Senator. Thank you.

Good morning.

On behalf of the 15,000 Westinghouse employees working around the --

CHAIR DOMENICI: Pull that microphone up.

DR. JACKSON: -- around the world and around the clock to keep nuclear power safe and secure, I would like to begin by expressing my thanks to President Obama and Secretary Chu for commitment to a strong, transformative, carbon-free nuclear power industry.

I also want to thank the members of the Blue Ribbon Commission and this Subcommittee for the opportunity to make some short remarks.

Westinghouse has been a leader in the nuclear reactor design industry for six decades. Of the 104 reactors currently operating in the United States, 62 of those are Westinghouse designs.

Westinghouse has vast experience in reactor design and innovation, most notably the AP1000, a breakthrough design in enhanced safety, performance, and fuel efficiency.

Other Westinghouse technologies include liquid metal fast reactor designs that are especially effective for reprocessing and remanufacturing fuel for optimum efficiency.

In the fifties, Westinghouse began assembling a world-class group of scientists and engineers and the resulting innovation of a standardized design, the AP1000, the flagship of our Generation-3+ product line. And since 1995, we have been investing in the development of small modular reactors that hold great promise for delivering environmental benefits to a broad array of customers.

When a Westinghouse customer anywhere in the world buys a reactor or a fuel product from us, they get the added benefit of our competency in licensing and nuclear regulatory affairs in the United States and internationally.

Nuclear U.S. policies represent the highest standards of regulated safety and environmental protection, and Westinghouse rigorously deploys those standards here and around the world.

But if we are to grow our American fleet in nuclear reactors, we must have a new and improved set of standards for fuel processing and management, and those standards must be as rigorous and sustainable as our safety and operating framework.

U.S. leadership on this policy will result in U.S. leadership in technology. This will provide greater certainty for worldwide safety and security standards. With more public investment in the earliest phases of the design and basic research, the U.S. will more effectively develop technology based on resulting standards and delivered solutions in the U.S. and international markets, and this means American jobs.

Westinghouse provides approximately 54 percent of the nuclear fuel to the U.S. pressurized and boiling water reactor market, as well as a significant share of the world market. This expertise and resource capacity provides us with exceptional understanding of fuel management, including physics, financial, technical, and regulatory aspects of every stage of the fuel cycle for almost every fuel.

Up until now, the industry has segmented the nuclear fuel cycle into pieces. Vendors and nuclear utilities have focused on the front-end, optimizing the efficiency and cost of producing both fuel and electricity. The assumption has been that the back-end will be optimized by the federal government, and that once fuel is used, payments made to the federal government by the utilities for waste management will cover the full range of back-end management.

This compartmentalization does not provide financial incentives for the improvement in front-end fuel efficiency, waste prevention or reduction, nor does it allow the needs or the requirements of the back-end objectives to drive improvements in the front-end for desirable back-end results. We believe that that practice must change, and we must manage the technical, economic, environmental, and policy issues as a coherent system.

With the perspective of the entire fuel cycle, we believe a physics-driven approach that begins with the determination of public acceptability is the most effective and viable new fuel policy path. The challenge for the back-end has been to take the existing legacy of used fuel and store it permanently.

Designing for safe, secure, and permanent storage has led to vigorous debate. How long is permanent? If we start with the goal, say a time for storage that is conceivable or understandable to the public, say 300 years, as a toxicity target, and a toxicity target at that time for no greater than the original uranium, then we can design back through the fuel cycle to achieve those targets.

Technologies developed for application to the back-end of the nuclear fuel cycle were designed decades ago in different policy regimes to address slightly different issues, and so, may not be optimal for use now.

For example, mixed oxide fuel production, which Westinghouse participates in, is a path that is currently available, and so we are pursuing it. But it doesn't reduce the volume of used fuel as significantly as we would like. We don't get significantly more energy from that fuel, and it produces greater amounts of minor actinides that might be needed to be handled later. So we do need investment in new technologies.

Redesigning the nuclear cycle for the back-end does help, but we are living with the legacy of light water reactor used fuel. Therefore, we need also to invest in technologies that dramatically improve fuel cycle economics and decreased waste stream, including technologies ranging from re-cladding and re-shuffling to some forms of recycling.

We think that the incentives need to be changed through new federal policy. Once a goal is established for final end product, this sets specifications for the technologies that must be developed. How much do separation processes have to work, how the reactor works for recycling, and how that cycle that Jack Fuller talked about will work.

Even if the Commission were to enact new requirements for fuel cycle integration with a physics-driven strategy, the industry would need adequate time to implement changes. The path from our current baseload energy portfolio to a mixed program where we produce an even larger portion of our power from nuclear fuel will require the development of new reprocessing technologies that achieve the required levels of bad-actor separation from the waste, as well as reactors that can handle the volume.

Besides technology, the U.S. must have a road map of how we will get from where we are today to a new era of nuclear energy. Ad hoc solutions that address only part of the problem will only lead to ineffective resource investments.

As I indicated, Westinghouse is investing in strategies to generate a rational approach for back-end fuel problems. We took on this task because we have a significant stake in finding a solution to high-level waste problems that's acceptable to the general public, as well as economically acceptable to our customers who supply low-cost carbon-free electricity.

We have significant capabilities to solve this problem and strong interest in finding solutions. Our technologies and product lines include advanced light water reactors, gas reactors, and fast spectrum reactors.

A few notable programs in which Westinghouse was a primary technology partner are the Fast Flux Test Facility and the Clinch River Breeder Reactor.

In the areas of high-level waste handling, Westinghouse was the prime contractor in a successful cleanup of high-level waste at both West Valley and Savannah River.

Our investments in this project produce invaluable lessons and expertise and unmatched capability. We have a team of experienced people familiar with technology needs to solve waste problems produced by the current reactor fleet and a growing number of younger people who are learning these technologies. And this really is an opportune time to leverage the transfer of technical knowledge of our experienced personnel to future experts who will become the backbone of the nuclear industry.

I will just sum with some recommendations.

Defining a new policy by starting with outcomes that are publicly acceptable, the prevention and reduction of toxicity and volume of used fuel are desirable and will drive investments in and standards for reactors and technologies that can produce those desired outcomes.

Develop a new fuel cycle policy using science as the means to get to acceptable outcomes. We must define what's publicly acceptable first and then use a physics-driven strategy to reach those targets.

Develop new, publicly-acceptable fuel policy with collaboration from all stakeholders. A successful new policy will need to focus on waste, acceptability, economics, and proliferation controls. Westinghouse advocates that a collaborative process includes the Department of Energy, which needs to act as a funding source to develop new separations and reactor technologies that meet public expectations; the National Labs, which need to serve as the brain trust to generate new technologies required by industry; the nuclear industry to develop low-cost technologies and products to solve those problems, based on the science and technology delivered via government.

How to communicate the things that we need from government in order to keep our business technically proficient and economically cost-effective.

And it includes the political process that must protect and promote a transformative national energy future of carbon-free baseload nuclear energy.

Increase government investment in research and technology development to shoulder a greater portion of the risk in early development projects. Government must offset the risk of exceptionally long time horizons, assuring private capital markets and companies that their investments will pay off.

Westinghouse competes with subsidized, nationalized nuclear energy companies, and we need a clear national policy goal for fuels. And we need to be assured that the government will take on the majority of risk in the early stages of technology development that will move the industry to new policy goals.

Increased funding for the Nuclear Regulatory Commission, so that it can build capacity to be involved in technology development. The sophisticated and collaborative licensing process of the NRC must be brought to bear early in the technology development process to identify issues that need to be addressed and reduce the risk of technical innovation later in the process.

To support this imperative, the

NRC needs more resources now to prepare for the technologies and processes that emerge from an integrated fuel cycle strategy. They will need to prepare to evaluate and efficiently perform testing to ensure public safety without delaying the industry, as it adapts to an integrated strategy.

But we must stay on two parallel tracks to resolve our legacy waste issues while taking action to create the future of a physics-driven policy. At Westinghouse, we believe that a fresh and effective policy framework for fuels could potentially alter the debate on disposition in a positive way.

Prevention and reduction of toxicity and reduced volume of used fuel are desirable. If we are investing in reactors that produce those desired outcomes, then we have new long-term storage options available to us.

But we must proceed on at least two tracks. While we pursue a long-term physics-driven strategy for the future, we must also work to get more efficiency from fuel through recycling technologies.

Spent fuel is, and will continue to be, stored safely in interim locations. In the short-term, maintaining our current storage policies can actually provide some flexibility for getting additional energy out of the current stock of stored used fuel that would otherwise be shipped to final disposition.

Mr. Chairman, again, on behalf of the 15,000 employees who take great pride in over 100 years of Westinghouse innovation in science and technology, I thank you for your service and serious consideration of our views and recommendations.

CHAIR DOMENICI: Well, you are welcome, ma'am. I was tempted to ask you would you take two minutes and give us a summary of a one/two, what you would do, but I think I won't. We'll get to you when the questions come.

And I would like to say to your 15,000 employees that you were speaking to that some of us are concerned about the future because we would like the fifteen to turn into thirty, if the world's going to move ahead.

DR. JACKSON: As would we.

CHAIR DOMENICI: As would you. But we had certainly better do some things or it won't be fifteen; it will come down instead of the other way.

So you've got to wish us well in doing the right thing.

DR. JACKSON: And we do.

CHAIR DOMENICI: Having said that, we will go to the next witness, and thank you very much.

Our next panelist is Alan Dobson, Senior Vice President of Energy Solutions.

Mr. Dobson, would you mind telling us what that means, that Senior Vice President of Energy Solutions?

MR. DOBSON: Yes. Chairman Domenici, Chairman Peterson, distinguished members of the Committee, I'm Senior Vice President responsible for fuel cycle and used fuel management within Energy Solutions. If you want to discuss that in more detail, I would love to do that a little bit later. But given that we're trying to move on, and I just have 10 minutes, I would like to give some of my remarks.

CHAIR DOMENICI: I won't take from your 10 minutes. Don't give it to him.

(Laughter.)

What are you, Energy Solutions? What do you do?

MR. DOBSON: Energy Solutions is a company which deals with nuclear waste. We were formed by the acquisition of a number of nuclear companies over the past six years. In my own case, I came from the old British Nuclear Fuels, a U.S. subsidiary of BNFL, Inc. And we provide used fuel management, waste treatment, and we have recycling technology, and we have developed recycling technology, for instance, for the Department of Energy under the GNEP program.

CHAIR DOMENICI: If I were to ask you if you're experts at something, what are you expert at?

MR. DOBSON: We're certainly experts at waste treatment, but we have great expertise in recycling and in technology application and development.

CHAIR DOMENICI: All right.

MR. DOBSON: So, for instance, Energy Solutions has developed the technology for dealing with the United States high-level liquid waste vitrification processes, and it is our technology that will be used at the Hanford Waste Treatment Plant, when it is completed, and has been used in other situations around the United States and around the world.

CHAIR DOMENICI: All right, we got

you. Now proceed. Your time hasn't been taken from you.

(Laughter.)

MR. DOBSON: Thank you.

Well, first of all, we were asked to address two questions today:

Are there technology options, including alternates to the once-through cycle, that offer significant potential to influence the way in which used fuel is stored and ultimately disposed?

And the second question was, are there federal actions that could facilitate commercial efforts to deploy those technology options while meeting, of course, safety, economic, environmental, security, and non-proliferation goals?

The short answer to both questions is emphatically yes, and we believe the nation's best interest is served by moving down a path to take the actions to realize those options.

I want to try to address just four things in my remarks today that will enable us to move forward. I want to talk about technology. I want to talk about technology demonstration. I want to talk about creation of a new government entity. We call that fed-corp. But, last, I want to talk about an integrated approach to used fuel management in which regional fuel management facilities would be created.

Taking each of these, technology availability. There are several technology options that are available. We have head about a couple of them today already. They have huge potential to beneficially impact the way used fuel is stored and disposed of in the U.S.

Options exist for fuel storage, recycling, and ultimate disposal that represent significant changes to the current strategy and, moreover, because of those changes, offer significant advantages. Some of those options require little development work and some require extensive development work.

Energy Solutions developed a comprehensive solution for closing the fuel cycle. It is based upon advanced chemical technology, but uses commercially-proven equipment that could be fully implemented today. And it would bring significant benefits in waste management and ultimate disposal.

It would reduce the volume. It would reduce the heat. It would reduce the radiotoxicity, and it would reduce the cost of disposal of the waste. But perhaps most significantly, it would open up alternative final disposal options.

It would have many more environmental impacts. Aerial and liquid discharges would be close to zero, and it would not increase proliferation risk. Plutonium would never be separated alone. It would always be with other transuranics, and plutonium would be consumed.

These ideas are more fully described in our GNEP deployments to this report, and we have submitted copies of that report to the Subcommittee. We would be very pleased to follow up on the topic of closing the fuel cycle, as we described it in that report, if it will help the Subcommittee.

The second aspect that I would like to discuss is technology demonstration. Although advanced technology -- and I do use the word "advanced" very carefully and very advisedly -- is available for deployment today, that does not mean that further R&D is not required.

Fast reactors, for instance, have significant potential to bring benefits, but more development work is required before commercial deployment is possible. That includes development work in the fuel cycle for fast reactors, especially if we want to exploit the fast reactor's ability to consume long-lived radionuclides such as the transuranics.

A key requirement, for instance, is to demonstrate that the thermal fuel cycle can be effectively integrated with the future fast reactor cycle. For LWR fuel recycling, our work has shown that aqueous processes are more suitable, the advanced aqueous processes are more suitable, but the non-aqueous processes, pyro or electrowinning, as they're called, may be better for the fast reactor fuel. The key question is, how do we bring them together?

We believe that a program leading to a large engineered and scaled demonstration facility is required. And in that facility, we would combine an aqueous head-end process to remove the bulk of the uranium from the LWR fuel, a transuranic separation and precipitation to provide fresh feedstock or an electrowinning process that's recycling fast reactor used fuel. It is appropriate that the federal government sponsor and fund such development work.

My third topic was a new government entity to manage nuclear fuel and nuclear waste. We believe that a significant change in the way the government discharges its obligations on UNF disposition is necessary. Energy Solutions and many other stakeholders consider that a new entity -- we called it fed-corp in our earlier work -- should be created.

It will have full responsibility for all aspects of used nuclear fuel management, interim storage, recycling, if that is appropriate, and establish the ultimate repository. It would receive a waste fee from the utilities and not be subject to annual appropriations.

A variation of this concept is being proposed in draft legislation by Senator Voinovich recently. We fully support that legislation.

Last, but by no means least, I would like to leave you with some thoughts on a different way forward, regional use fuel management facilities. Closing the fuel cycle is an important issue, but we believe it is just part of what we termed a new integrated approach to used fuel management.

We all know, perhaps we all hope, that global and national energy and environmental issues are dragging towards a continued and expanded commercial nuclear energy. Disposition of the used nuclear fuel is an issue that we believe must be satisfactorily resolved to sustain that expansion in nuclear energy.

Currently, our UNF policy is in transition, but a new commercial-based approach we believe can break that deadlock and enable us to move forward.

The realities of the current situation are significant political and commercial uncertainties remain on the timing of a large-scale, i.e., industry or commercial recycling facilities. Any future operational alternative geology disposal site is many decades away.

On the questions of timing, Energy Solutions has always been consistent in this view, that the primary drivers for recycling to make sense are economics and strategy, and the key issue is a significant new build program. That may be some ways off, but we do think it is important to have a solution for the UNF now.

We could, of course, just leave the nuclear fuel where it is. We know that current at-reactor storage is safe. Or we can try to find a new way forward, and we would urge the Commission to try to find that new way forward.

In our vision, this new initiative would comprise three main elements: regional used fuel management facilities, advanced fuel cycle and reuse development, and geologic repository development and deployment.

Regional commercial UFMFs, Used Fuel Management Facilities, can provide an effective bridge to an evolving national policy for used nuclear policy. It does not preclude commercial recycling. In fact, such a facility would be an ideal location for a commercial recycling plant, when the time is right.

This way forward is based on a strategy that incorporates lessons learned from the many previous initiatives. It would have a phased integrated approach. It would be a competitive, commercial, private sector initiative.

Federal government funding for the best approaches, to identify the best approaches from commerce, would be used initially.

There would be multiple regional volunteer host facilities. There would be binding agreements with incentives and penalties for those host facilities, but binding between all of the entities taking part in this initiative.

There would be comprehensive life-of-facility host benefits. And, of course, this option does provide the flexibility for final disposal options and for continuing the important research and development to find a solution for closing the fuel cycle that is acceptable to industry, to government, and to stakeholders.

Regional or centralized bridging integrated used fuel management facilities that begin operation as interim storage facilities and are capable of evolving into advanced technology facilities are needed to relieve the pressure on operating reactors and remove the 4,000 tons or so of fuel that is at the permanently shutdown reactors. And this would restore public confidence that waste from nuclear energy will be responsibly managed. Again, we emphasize that these facilities would be located on volunteer sites.

Under such an integrated approach, we might locate substantial technology demonstration facilities that I described above. It would be a significant inducement to the volunteer community.

So, to summarize this alternate way forward, we are advocating a phased development approach that starts with the lessons learned from past experiences and includes a balance of technology, social concerns, economics, and politics.

The private sector plays a key role. They would build, own, and operate the facilities. It does depend upon volunteer communities, but we think they can be found. It needs an effective process to find those volunteers and build upon existing progress.

UNF disposition remains a federal commitment, and there are significant legal, political, economic, regulatory, and social drivers and challenges in order to make progress going forward and enable the government to address their UNF obligations and to support new reactor development within the next few years.

Again, we have made available to the Subcommittee a detailed report on this alternate way forward that gives an indication of the cost, the schedule, and discusses significant detailed key aspects and steps necessary to create regional used fuel management centers.

This concludes our remarks. Thank you.

CHAIR DOMENICI: Thank you very much, sir.

The next panelist is Dr. Ed or Edwin Lyman, Senior Scientist at the Union of Concerned Scientists.

Dr. Lyman, we welcome you and thank you for giving us your time.

DR. LYMAN: Thank you.

Do you have my PowerPoint presentation or was it too late?

CHAIR DOMENICI: Did you want to do that?

DR. LYMAN: You don't have it? Okay.

CHAIR DOMENICI: Can we accommodate him?

MR. FRAZIER: We could switch the order and load --

DR. LYMAN: No, that's all right. I'll just read it. Thanks. I'll provide the PowerPoint --

CHAIR DOMENICI: If you want to switch it, it should be fine.

DR RESNIKOFF: I have a PowerPoint presentation, too.

CHAIR DOMENICI: Oh, well, then we can't.

MR. FRAZIER: I'm pretty sure we have yours.

CHAIR DOMENICI: Okay, let's go ahead. You can do all right without it?

DR. LYMAN: Yes, I'll just read. Thank you.

I would like to thank the Chairmen and the Commission for the opportunity to present the views of the Union of Concerned Scientists on this issue.

I would just like to say --

CHAIR DOMENICI: Go ahead.

DR. LYMAN: The Union of Concerned Scientists is not an anti-nuclear organization, nor are we a pro-nuclear organization. We are open to any sensible idea that will help to mitigate climate change, but for that reason, we believe that going from the once-through cycle to a cycle involving reprocessing of spent fuel would actually hinder, rather than help, the development of nuclear power in the world.

There's a simple reason for this. This is because reprocessing will, in exchange for a highly speculative reduction in long-term risk, incur significant near-term risks. And these risks include the risk of nuclear proliferation and nuclear terrorism associated with the production of weapons-usable materials and large quantities in commerce, and, also, the increased health, safety, and environmental risks associated with processing spent nuclear fuel.

In our judgment, these increase the risk unacceptably in the near-term and, therefore, we do not see any credible path forward for implementing reprocessing, including any of the proposals that we have heard here at the table today, because we do not believe that they would achieve a significant benefit in any of the characteristics associated with waste management. In particular, I would like to focus on three today.

The first is that there would be no significant reduction in the inventory of actinides for a very long period of time, and these systems would be very ineffective at achieving that.

The second, with regard to waste volume, and I understand that the Commission has already discussed whether or not volume is a relevant characteristic for nuclear waste disposal --

CHAIR DOMENICI: Would you state the first one again for everybody?

DR. LYMAN: Yes. The first one is that the systems that have been identified to date are very ineffective at reducing the total inventory of actinides in the nuclear fuel cycle. They reduce the inventory at a very, very slow rate.

CHAIR DOMENICI: Got it.

DR. LYMAN: The second is that the volume reduction in high-level waste generation is marginal associated with any of the processes that we have heard here today. And if you include the volume of additional waste, low-level waste, greater-than-Class-C low-level waste, and other separated materials, that the total volume of waste to be disposed of would significantly increase.

And third, there is no significant reduction in the proliferation of nuclear terrorism risk associated with the modified fuel cycle concepts that have been discussed. And in particular, the notion of having plutonium that is not separated from other transuranics provides very marginal benefit with regard to either the risk of theft of nuclear material or the risk that that material can be used directly in a nuclear weapon. That has been demonstrated by National Laboratory studies over the last several years.

So, in response to the first question, we do not believe that there's any significant beneficial impact associated with any of the reprocessing strategies that have been identified to date.

And with regard to the second question, we do not believe that it is appropriate for the federal government to promote commercial fuel cycle options other than its legal obligation to develop a geologic repository.

And another responsibility of the federal government is to set policy and standards through the implementation of regulations, and we believe that it's appropriate for the Nuclear Regulatory Commission to achieve greater safety and security through a policy of expecting new facilities to have significantly greater standards with regard to safety and security than they do today. Unfortunately, the current situation does not reflect that, in that the Nuclear Regulatory Commission's policy is that new facilities need not be any safer than the facilities that exist today.

And with regard to security regulations, there is an effort underway to potentially weaken the existing security regulations on special nuclear materials, which would be a step in the wrong direction.

And with regard to the effectiveness of recycling strategies, a number of studies, dating back to the National Academy of Sciences' STATS Report in 1996, have demonstrated that, even when you have an actinide recycle system that has very high performance features, you know, it's essentially the perfect system for this objective, that it will take hundreds to thousands of years to significantly reduce the end-process inventory of actinides if the system is working perfectly. And in our view, that is not an effective system to reduce the actinide inventories which advocates of recycling claim is necessary in order to reduce the heat loads to the repository.

The most recent study in this regard was done by EPRI, and I understand that those results were provided to you at the last meeting, but I would like to reiterate them because I think they're important.

Essentially, implementing a system, again, with nearly perfect characteristics would not lead to a reduction in the existing actinide inventories when you start. In fact, EPRI showed that the total actinide inventory in the system would increase by about a factor of three over where we are today, and then, essentially, would stabilize at about three times the current inventory.

And if you compare that to a system where you have constant nuclear power on the once-through basis, it would take hundreds and hundreds of years to reduce the relative actinide inventory by a factor of, let's say 10, which we would consider significant.

Now this is important because we believe that the principle of intergenerational equity, which does govern the rationale for having a geologic repository in the first place, is a relevant standard here.

The OECD, the Nuclear Energy Agency, has defined intergenerational equity with a number of characteristics. I will just read one.

"Those who generate the waste should take responsibility and provide the resources for the management of these materials in a way which will not impose undue burdens on future generations."

And with regard to the standard, any recycling approach which takes hundreds or thousands of years to actually achieve a significant reduction of actinide inventories fails the intergenerational equity test because we are imposing the burden on future generations to continue to build and operate the same facilities that we have today and incur the accompanying increase in risk to health, safety, proliferation, and terrorism.

So, we simply think that these systems, because of their slow, sluggish ability to actually impact actinide inventories, do not meet the intergenerational equity test.

With regard to the question of volume, I would just like to point out that the technologies that have been identified do not have the significant impact on the volume of high-level waste.

Putting aside for the moment whether or not volume is a particularly relevant characteristic for nuclear waste disposal, something like the PUREX or COEX processes pursued by AREVA do not have the significant impact on the reduction of high-level waste volume. In fact, calculations based on French estimates indicate the reduction in volume of high-level waste is only about a 20 percent reduction compared to the volume of the initial spent fuel, which, again, we don't regard as significant.

With regard to proliferation and theft-resistance, the question that needs to be addressed is: are there any credible alternatives to PUREX that would be substantially more proliferation- and theft-resistant and would not significantly raise the risks of nuclear proliferation and nuclear terrorism relative to the once-through cycle? And if such an approach can be found, would the technology be secure enough to transfer it freely to any country that wants it? And on what basis could the U.S. deny its transfer, if it is deemed to be proliferation-resistant?

The solution to this is that, like Mr. Hanson said, proliferation-proof recycle doesn't exist. We would also say proliferation-resistant recycling doesn't exist. And whether it's UREX-plus or COEX or pyro processing, the results of recent studies have indicated that there is no significant reduction in the self-protection -- or increase in the self-protection of these materials if you mix them with transuranics.

And in fact, those mixtures themselves are still attractive for weapons. Even if they're directly used in nuclear weapons, those mixtures are still attractive. And I would refer you to the National Lab study that was conducted by Charles Bathke that I hope you will consider very seriously in these deliberations.

And I hear the beep, so I'll stop there. Thank you.

CHAIR DOMENICI: I want to thank you very much for your time, your effort.

Our last witness on this panel is Dr. Marvin Resnikoff, Senior Associate of Radioactive Waste Management Associates.

We welcome you, and we're glad to hear from you.

DR. RESNIKOFF: I'm pleased to be here, Mr. Chairman.

You didn't ask me who we are.

CHAIR DOMENICI: Does anybody care

to ask him that question?

(Laughter.)

DR. RESNIKOFF: Oh, good. What should I do? Just wave my hand when you should transfer to the next slide? Oh, thanks.

I'm familiar with the West Valley plant. That's where I started investigating nuclear fuel reprocessing back in 1975 as a volunteer for the Sierra Club.

There was much euphoria when the West Valley plant was sited. The Governor stated that it would make major contributions to the State economy, but little did he realize that it would all be negative.

That is to say, the State may spend up to $1 billion attempting to decommission the site, of the $9.4 billion which is estimated for the cleanup.

Just to relate what the economics of the West Valley site were, the plant cost $32.5 million to construct in 1963 dollars, much of it backed by the State. The plant processed 625 tons of fuel, brought in revenue of $22 million, and the estimated cost to decommission the site is $9.4 billion, if all goes well.

The local residents are not happy with the level of decommissioning. They would like the waste tanks removed as well.

Some of these points have been already emphasized by Dr. Lyman, but let me just say that perhaps the primary purpose of plutonium recycling is not to solve the waste problem. Perhaps the primary purpose is to remove the fuel from reactor sites to somewhere else, convert it to high-level waste, but it won't solve the waste problem in the end.

Concerning volume reduction, chemicals must be added to nuclear fuel in reprocessing in order to separate out plutonium from uranium. At West Valley, the final volume was approximately 25 times the initial volume that was brought into the facility. And this doesn't include the sludge waste that still remains at the bottom of high-level waste tanks that the Department of Energy does not intend to remove. With an advanced fuel cycle, more chemicals must be added, so the volume would even be greater.

The repository size is primarily a function of the heat, initial heat, and also the time for cooling the fuel. And reprocessing will do little to affect that, because it's primarily cesium and strontium that have to be reduced before the volume can be reduced at the waste repository. So whether it's MOX fuel or whether it's just ordinary uranium fuel, the repository size is going to remain the same.

A self-sustaining plutonium recycle program uses one-third MOX fuel, two-thirds uranium fuel in the reactor, in a light water reactor. So, the actual saving of uranium pertains to the one-third portion.

A lot of these issues actually were brought up in the GESMO proceeding before the NRC in 1980, as you know, Dr. Carnesale.

Because of the buildup of uranium-236 in uranium, which is a neutron poison, and the low uranium-235 content of recycled uranium, the uranium in MOX fuel is not recycled. So uranium is essentially a waste product.

The advanced fuel cycles essentially will remove americium, curium, neptunium, and will separately burn these materials. The separation must be very clean. And in addition, one must have fuel-burning americium, curium, cesium, and neptunium fuel-burning reactors in order to remove these materials. Once they are removed in the reprocessing stage, one has to burn them, and one has to burn them in these high-flux reactors. Tom Cochran is going to talk about the viability of breeder reactors in his talk.

In a 10-minute talk, I don't have

the time to discuss the initial steps required and the level of separation required to lower the toxicity of high-level waste in the long-term, but I have attached a paper that discusses the matter in more detail.

Fission products must also be dealt with in separating the high-level waste, and iodine-129 is the most difficult to capture in a reprocessing operation. And if it's separated, then what? What does one do with the iodine-129? As a very small neutron cross-section, one can't really reduce, one can't really separate -- what am I trying to say? One can't really change iodine-129 to iodine-131, which has an eight-day half-life, because it has such a small neutron cross-section. So what does one do with iodine-129, even once you separate it?

My conclusion is the poor economics and the difficulty of siting a commercial reprocessing operation, because of the experience at West Valley, means that only a government operation is going to be possible. The cost of West Valley at $32.5 million has now been escalated in recent reports to $6.7 billion for a reprocessing operation. So, economically, it does not make sense to reprocess fuel.

But I see the push for reprocessing as a means of simply removing the spent fuel from reactor sites, but not as a means of solving the waste disposal problem.

The Commission should recommend to the President separation of these minor actinides. Transmutation has been suggested as far back as 1975 in a classic paper by Claiborne, and not much progress has been made since. So my recommendation is the Commission should recommend to the President that, after 35 years of funding for plutonium recycle and separation of minor actinides and transmutation, that program should cease.

For various reasons, it makes more sense to store spent fuel in hardened storage at reactor sites, allowing the heat-producing radioactivity to decay away.

Thank you, Mr. Chairman.

CHAIR DOMENICI: Thank you very much.

Now we will keep the panel here for a little while, while the members of the Commission, if they desire, inquire of any of you or all of you. I'll start with a few softballs and let some of these other people give you some zingers. Okay?

(Laughter.)

Are the current federal or state policies that either assist us in achieving or hinder our ability to achieve goals, are there policy options that could, if enacted, further assist us in achieving these goals?

Let me go back and talk about the goals for a minute. From the panelists' perspectives, what are the most important social goals that new nuclear reactors and fuel cycle technology can help us achieve?

And what are the policy goals that currently impact decisions about nuclear power?

Do you want to start, either Dr. Hanson or the second person?

DR. HANSON: With regard to policy, at the conclusion of my statement I alluded to what I thought was the most important thing that needs to be done. After 40-some years of nuclear power development in the United States, we have, in fact, made some progress towards waste disposal, but, in fact, very little.

I think part of the reason for that is we are trying to have a government agency operating in a political environment accomplish an industrial/commercial type of activity, a large-scale engineering project, and a government department or a ministry in a parliamentary system is not the adequate vehicle in order to do that.

The places in the world where we have seen successful waste management programs are ones in which the responsibility for waste management has been delegated by the government to either some sort of semi-government organization or to the private sector, and given them the latitude to go ahead and solve the problems.

I think this is certainly true in France, in Finland, in Sweden, and I think that we ought to follow that example and change the policy in the United States to remove the responsibility for industrial work from the current Department of Energy.

CHAIR DOMENICI: Thank you very much.

Anybody else want to try? I'm trying to get at the most important societal goals that new nuclear reactors and fuel cycle technologies can help us achieve. What are the policy goals that currently impact decisions about nuclear power?

MR. FULLER: Yes, Senator, let me take a shot at it.

CHAIR DOMENICI: Please.

MR. FULLER: My view is the No. 1 impediment to expanding nuclear power in the United States is the issue of the fuel.

CHAIR DOMENICI: Issue of what?

MR. FULLER: Is the issue of the spent fuel coming out of the reactors. Until we solve that, and we solve it in a fashion that gives the public a certainty and a safety factor and a confidence that we can do that in a proper way, I think we're going to be at an impediment of expanding our nuclear fleet.

It's currently at about 20 percent of the U.S. energy generation in the U.S. It probably should be 40 percent or 50 percent to provide energy security for our country going forward.

So I think this policy issue is to provide a long-term vision from the government that spans multi-generations of the political environment, that says here's where we need to go, here's how we're going to go there. And once the public, the general public, has that clearly understood and accepts it, I think we can move on with not only solving the used fuel activity, but expanding the nuclear activity in this country, and coming again to the forefront of the technology.

We have the ability to innovate the technology. We just don't have the will right now. So, that's what I would like to see from a policy point of view.

CHAIR DOMENICI: Very good.

Dr. Jackson?

DR. JACKSON: Well, I think I would echo what Mr. Fuller said. I think that nuclear power offers the opportunity to provide a solid foundation for a low-carbon economy, and growing that footprint of nuclear is important, but absolutely dealing in a coherent way with the used fuel is critically important and having it be a publicly-acceptable solution.

So the expansion of nuclear power

is critically important to be able to provide a strong baseload to integrate all kinds of renewables and other environmentally-beneficial kinds of energy supply for a strong economy in the United States, but beyond that, leading technology and developing standards are critically important.

Notwithstanding what the United States decides to do, there will be technologies developed. So developing those technologies that are best used to be able to handle some of these challenges I think is critically important.

So establishing a federal policy that survives multiple election cycles is crucially important. So, for that reason, we are, in addition, supportive of some sort of federal corporation.

I worked for the Tennessee Valley Authority for 17 years, and so I'm quite fond of the Tennessee Valley Authority's ability to be able to integrate the public's needs, multiple constraints, managing in an integrated way, and design a set of policies that can be implemented in a flexible way over a long, long period of time.

CHAIR DOMENICI: Does somebody else want to comment?

MR. DOBSON: If I could, I agree with everything that has been said. I would just like to draw one important point, a distinction.

So I do think it is important, Energy Solutions believes it is important to create a new government entity, the fed-corp, as we described it, to deal with the used nuclear fuel.

And we do absolutely agree that dealing with used nuclear fuel is the pressing issue with regard to a large expansion in nuclear power. But you don't need both. Sorry, we need to do both, but the second is not dependent on the first, is the point I want to make.

So we could press ahead with regional used fuel centers without the creation of fed-corp, although I would say the creation of that new government entity is very important.

CHAIR DOMENICI: Got you.

Dr. Lyman?

DR. LYMAN: If I may, I would just like to reiterate. One of our chief goals is to prevent an expansion of the risk of nuclear terrorism and nuclear proliferation. Nuclear power is a dual-use technology, and those risks really need to be tightly controlled, if we are going to be able to see an expansion.

So, to that end, we do believe that the decision made by the United States many years ago to forego reprocessing has had a beneficial impact on keeping that, the threat, in check. We are concerned that a reversal of that policy could have an extremely negative effect, especially on the rest of the world, by signaling to them that reprocessing is a desirable or worthwhile process to undertake, which could lead to losing control over the technology around the world.

So, to that end, we would think that the best thing the United States could do is to demonstrate the viability of a process for developing a geologic repository for direct disposal of spent fuel, to show that it is technically and politically feasible. And that signal could help resolve some of the confusion with regard to the disposal of nuclear waste that's plaguing us today.

Thank you.

CHAIR DOMENICI: I appreciate your observation very much, Doctor.

I would like to say, however, it appears to me that, while we sit around and think about this issue, the world is moving ahead with the development of nuclear power plants. The United States has some problems in doing it. Hopefully, this Commission will clarify something and say what our policy should be.

But you would have to agree with me that with China having maybe 13 power plants, and around the world you can identify them, it looks like we can talk all we want about this, doing what you recommend, but the world isn't going to do that. They're moving ahead rather rapidly.

DR. LYMAN: Well, I do believe that we do have the opportunity to influence policy through a variety of means. I don't agree with the argument that we need to engage in reprocessing ourselves to be able to influence other countries.

CHAIR DOMENICI: Oh, yes, I didn't say that. I said something else.

DR. LYMAN: But I do believe that the U.S. actually has a number of tools at its disposal which it chooses not to use to try to limit the spread of nuclear weapons-usable materials.

For instance, much foreign spent fuel is U.S.-obligated. Under the Nuclear Non-Proliferation Act, we, if we chose to, could impose significantly greater obligations on those countries. Yet, in many cases we have weakened those obligations and not used the tools we have.

CHAIR DOMENICI: Let's see, Al, did you have another question?

MEMBER CARNESALE: Dr. Hanson, maybe you can help me understand a little bit with putting together that only 4 percent of the fuel is waste, together with you said it would reduce uranium need by 25 percent, not by 96 percent. You said that 30 percent of the plutonium would be burned, not 100 percent. So I'm trying to figure out, what is it 4 percent of that it's only 4 percent, rather than a much higher number?

DR. HANSON: The 4 percent consists of all of the fission products plus the minor actinides, the higher isotopes above plutonium.

MEMBER CARNESALE: What about all the uranium?

DR. HANSON: The uranium is removed and recycled into fuel.

MEMBER CARNESALE: Well, then, how come it's only reducing uranium need by 25 percent?

DR. HANSON: Because it's the 235 content that is recycled, remember, not the --

MEMBER CARNESALE: So it hasn't reduced the waste down to 4 percent?

DR. HANSON: Yes, it has. It has reduced the waste which must go into the geologic repository by a large volume, not the 20 percent we've heard here --

MEMBER CARNESALE: Yes.

DR. HANSON: -- but 75 percent, yes.

MEMBER CARNESALE: Yes.

DR. HANSON: Not 90 --

MEMBER CARNESALE: Not 96 percent.

DR. HANSON: It's closer to 75 rather than 96.

MEMBER CARNESALE: At most. Okay. Well, that helps me with the fact.

Then I would like to ask about reprocessing. One of the problems we have is this misinterpretation of what the U.S. policy was that came under the Ford and Carter Administrations. It did not prohibit reprocessing. It said the United States Government would not pay for it. It permitted reprocessing, but the U.S. Government wasn't going to pay for it.

I would like to understand, do any of you believe that today that recycling and reprocessing in light water reactors is economically attractive without government subsidy? Do any of you believe that it is?

MR. FULLER: If you take the Japanese model right now, the Japanese are using mixed oxide fuel in light water reactors.

MEMBER CARNESALE: Yes.

MR. FULLER: It is very costly. It is not supported by government. They are paying for it through the utilities, through the TEPVO and the JAPC and such. They have decided that the economics are secondary to the reprocessing activity. So that's the way I would answer that.

MEMBER CARNESALE: Right. That is an answer to a different question. But in terms of economically attractive, it is not. That was my understanding. There may be other reasons for doing it. Don't get me wrong. But that is something that has not changed.

And finally, I would like to ask, with regard to the economics of nuclear power today, there are many reasons for its being attractive, low carbon, et cetera, but it is my understanding that it is not economically attractive, that it, too, requires government subsidy compared to carbon fuels. Lots of disadvantages of carbon fuels, but is there anybody who believes that building and fueling nuclear plants today would be cheaper over the long-term, if you had to pay for the whole thing over the long-term, than continued burning of fossil fuel or, in particular, adding, say, a natural gas plant?

MR. FULLER: Just a wonderful debate. If you take the current nuclear fleet in the United States, because of the age of that fleet and the operation, the capacity factors, and the fact that today it's into a maintenance and fueling load, it is the least expensive --

MEMBER CARNESALE: Oh, I know. That's not my question.

MR. FULLER: -- form of generation.

MEMBER CARNESALE: Excuse me. It's not my question. My question is --

MR. FULLER: If you take --

MEMBER CARNESALE: -- adding a plant --

MR. FULLER: If you take the future fleet, the key question is not what the initial cost is of a new nuclear plant.

MEMBER CARNESALE: Right.

MR. FULLER: It is, what is the cost of the carbon-based fuels that it competes against?

MEMBER CARNESALE: Yes.

MR. FULLER: So, if the gas prices are very low, like they are today, it makes no sense. If the carbon or the gas prices go up above a certain level, you suddenly find that nuclear becomes the option.

The fact is that it takes five to eight years to place a nuclear plant in place, and most utilities will not take on that risk without some certainty around it, which goes back to government guarantees.

But in the long-term over 60 years, I think if you look at any kind of generation, you will find that nuclear is probably the least expensive over that timeframe because of the fluctuations in the hydrocarbon markets, et cetera.

MEMBER CARNESALE: Because of what you expect to happen to the price of gas?

MR. FULLER: What may happen or doesn't happen, that's the problem. As a businessman, what I would do is say it all depends on how you project that future.

MEMBER CARNESALE: Yes, but I haven't heard any utility that is interested in building a nuclear power plant without government subsidy, whether in the form of loan -- by the way, this is not a negative statement about nuclear power. There are other reasons for doing it. I just want to be careful --

MR. FULLER: I think to clarify that, it is no utility --

MEMBER CARNESALE: -- to make sure we don't -- this industry has a long history of overpromising that has gotten us in big trouble. I want to make sure we don't make that mistake again.

MR. FULLER: I think that's fair, but that's no utility in the U.S. There's utilities outside the U.S. that have decided to implement nuclear power because of government policy, because of carbon issues, because of other issues, and they are economically placing those plants into operation such as in Japan right now.

DR. HANSON: If I might add, and I don't want to get into a big debate about nuclear power, but one of the problems is you use the word "economical". What does that mean?

The implication is that is the lowest cost, that it is cheaper than anything else. That is not the definition of economical. People make decisions all the time about what they purchase and what they invest in based on cost and all kinds of other factors.

If we want a subsidy-free, lowest-cost generation in the United States, we should continue to burn coal as fast as we possibly can, and they should do the same thing in China. And I don't think anybody wants to see that done.

MEMBER CARNESALE: I agree with you. That's why in my question I said there are other reasons for doing it. I want to separate out the economics.

DR. HANSON: The same is true, by the way, of recycling. It is economical in the sense that the difference between throwing away the fuel and doing thermal recycle is in the single digits. It may be plus or minus 5 or 6 percent, which is our experience in Europe. It may be less; it may be more. But this is not a deal-breaker with regard to doing recycling.

DR. RESNIKOFF: Dr. Carnesale, I just wanted to reiterate a point that you made. What you said about nuclear power plants applies more so to reprocessing plants.

There's no one who is going to have a reprocessing plant unless it's government-subsidized. No one is going to put up $6.7 billion with the risk involved, unless there's a government subsidy.

MEMBER CARNESALE: I want to make it clear that there clearly are other reasons for doing it, and I understand that. I just want to be careful that we don't confuse the issues and have it appear that we are doing it for economic reasons as opposed to for these other reasons.

CHAIR DOMENICI: My Co-Chairman would like to proceed with a few questions now.

CHAIR PETERSON: Thank you.

Actually, the question that I would like to bring before this panel follows from Al's question, and it relates to the questions associated with first-of-a-kind risks and first-of-a-kind costs and first-mover issues and market failures associated with free-rider problems.

The reason I would like to bring this question before the panel is because we have three representatives who are from companies that have been actively involved in the construction of nuclear reactors or licensing of new reactor designs here in the United States, and therefore, have experience from that perspective.

And I think this is an important issue within the nuclear field. As I mentioned in the opening, there are other heavily-regulated technologies where the United States is clearly a leader in the world, such as commercial aircraft, drugs, medical devices.

So one question would be, what are some of the things that differentiate nuclear energy as a technology that may tend to make it much harder for first-movers to bring better technologies to bear?

And I would like to focus on a

specific example that actually comes from the AP1000 licensing process. Actually, it is interesting because it is analogous to something that was happening back early in the last century.

It turns out that what we now call safety glass was invented in France in 1903. And for those who aren't familiar, safety glass is what you get when you laminate two sheets of glass together with a sheet of plastic in between them.

There was a French scientist, Edward Benedictus, who observed -- there was a flask in his laboratory that he had been mixing some materials in, and it had dried out rather than being properly cleaned. And his assistant knocked it to the floor and it fell down and it broke, but it didn't fall apart because there was a layer of plastic on the inside.

Actually, this was a huge observation. He patented it. It was not applied in automobiles for another quarter of a century. And it was in 1927, actually, that Henry Ford brought this technology into the Model A. Of course, today we take for granted safety glass as a technology.

So now we can fast-forward to today, and we have a similar issue with reinforced concrete. Reinforced concrete is actually a brittle material. We use it in nuclear power plants, and we make them extremely thick and robust because of the fact that there is a limit to the strength.

If one, instead, sandwiches the concrete between steel plates, which is referred to as steel-concrete composite construction, then the concrete will behave as a ductile material and you can move the manufacturing into a factory environment, which has a whole host of implications because now you have materials that will behave in a ductile way, even when they are driven to substantial limits, say in an accident.

And this is a technology that Westinghouse has actually now implemented in the AP1000. I think it involves some pain getting it licensed because Westinghouse is the first-mover.

The Koreans are coming behind in their design with exactly the same technology. They will have a much easier time.

So this, I think, is a serious issue. Maybe I would like to ask Kate to comment a little bit about some of the issues of bringing something new into the nuclear field versus other industries, and perhaps what might be some solutions to make this less of a barrier, so that we see more rapid innovation.

DR. JACKSON: Well, I think one of the reasons that the nuclear industry has been so successful at improving its operations and improving the availability and capacity factor of plants and reducing the amount of safety and security problems has been its track record, its examining operating performance, its sharing of lessons learned. It's based on history.

So all of those long-term data and access of those data drive what we do in the future, both from the design perspective and the licensing perspective, but also the operating perspective.

So we all rely on that history, and the regulator relies on that history. As a result, the regulatory process looks back, as does much of law, into precedent and to find what works and what doesn't work and how you can address new challenges in design and technology development, given that historical background.

So, when you try something new that will clearly solve problems, and it's technically-acceptable, the NRC still needs to look back and ensure that there are standards acceptable, so that it can ensure public safety. That's critically important. It is painful.

The AP1000 not only did the composite construction, but, in addition, the modular construction, which is essentially Lego-building, which decreases that time. We talked about eight-year construction of a plant. The Chinese are going to do it in three.

So, as we have transferred technology for that modularity, that has driven lots of opportunities. The AP1000, in addition, because of its passive safety, we took almost a decade to really -- we say it in a flip way -- but to license gravity.

So those things that we know will work, you have to show that it will work in an integrated way in a very complex systems design. And because the cycle times are so long for development and the technologies are complicated, and they are incredibly expensive, it is difficult for any one vendor to invest in that long-term, which is why I said it is crucially important early-on in the technology development cycle to have the federal government have a greater portion of that investment risk, until the clear goals are established and then industry can take over and deliver products and solutions to the marketplace.

CHAIR PETERSON: So, to emphasize that this is an area where you cannot patent an NRC decision to license something that's new, such as a new approach for a control room, if you're talking about small modular reactors, or in this case a new construction technology that is something that is very difficult to patent any element of it.

And therefore, the effective approach to bring innovation in the market is to provide some federal cost-share and subsidy, which goes, I think, to also address Al's question about the issue of building the first few nuclear plants. When you have first-of-a-kind risks associated there, and you have utilities that will probably say they want to be No. 2 in constructing nuclear plants, this is an issue.

But I think it also gets to -- and I'll transfer the question over to Ed Lyman -- this question of, how do you set higher expectations and how do you improve these technologies, so that the new generations are substantially better than the previous ones, given that you have these difficulties for vendors to bring anything new into the NRC?

Would you agree that at least some type of federal cost-share for companies that are bringing new technologies is an appropriate way to incentivitize better technology to get into the market?

DR. LYMAN: Thanks, Per. I would like to speak on a personal basis, as opposed to representing UCS because I think there are probably a diversity of views in the organization.

But I do believe that in order to

achieve significant increases in safety and security, that it is appropriate to raise standards across the board. And to the extent that those could lead to features that are non-competitive, in other words, if you have to pay extra to goldplate a nuclear power plant, then it might be appropriate for some sort of government assistance to ensure that that additional significant level of safety is something that can be built and operated and will work.

But the first step is really to have a policy that strives for significant improvements in the next generation of nuclear power plants as opposed to the current policy of the Nuclear Regulatory Commission, by not requiring that the new generation of nuclear power plants is significantly safer than the current generation. I think that plants, certain plants, have been penalized for introducing safety features that are not absolutely required by the current regulations and that are more expensive. And as a result, we may see a loss of market share to those plants that do have those additional features to ones where they have cut corners or essentially maintained the same level of safety as current plants.

So the first step needs to be a clear policy by the NRC to see across-the-board improvements of safety. Well, of course, if there is a level playing field, there may not be a need to help subsidize the better performers.

CHAIR DOMENICI: Thank you very much.

Now I am going to note that the various Commissioners have sought to ask questions, and I'm not sure how much time we have. But let me state them, so that we know up here.

The General wants to ask a question, and he's next. Then Allison wanted to ask a question, Phil Sharp, and Susan

Eisenhower. We'll go in that order. Mr. Chairman, you're next.

MEMBER SCOWCROFT: I just have a quick question for Dr. Lyman. That is the real nature of your opposition to recycling and reprocessing. I applaud your concern of proliferation.

Suppose we dealt with proliferation by internationalizing the fuel cycle, so that we stopped national enrichment of uranium, national reprocessing. Would you still oppose reprocessing and recycling as a way to improve the effectiveness of the fuel cycle?

DR. LYMAN: Thank you for your question.

We don't oppose the attempts to try to get greater international control over the fuel cycle. So far, they haven't been all that well received by a lot of countries around the world, which is frustrating.

We believe that is an appropriate

model for uranium enrichment, if it could be implemented, but we don't think that those arrangements would necessarily reduce our concerns with regard to reprocessing.

It depends on how you arrange the fuel cycle. But to the extent that you continue to have to transportation of weapons-usable fuels to countries with power plants, the increased transportation risk associated with transporting MOX fuel, for example, would remain a concern that would not be necessarily addressed by internationalizing the fuel cycle facilities themselves.

CHAIR DOMENICI: Thank you for the question, General, and thank you for the answer.

But let's proceed now. Allison, you're next.

MEMBER MacFARLANE: Okay, great. Thanks. I will limit myself to three questions for three of you.

So the first one is to Alan. Just

in general, I think back to Al's question, part of public acceptance, which a couple of you mentioned as being important, is good economics. So just keep that in mind. It's not just that it has to be safe, but if you want something to be acceptable to the public, you have to make the cost good, too.

Alan, I was interested in, first of all, why you are shying away from advanced reactors, fast reactors in particular, and what some of your critique is there.

Then, secondly, back to the volume question, I will reiterate from the point of view that volume is not the relevant unit of measure. But I'm interested in what you propose that the U.S. do with its spent MOX fuel, which, by the way, over the long-term gives off three times the heat of spent LEU fuel. And therefore, it takes up three times the capacity in the repository. And that's my first question.

DR. HANSON: I assume when you

said "Alan", you meant Alan Hanson since we have two Alans.

MEMBER MacFARLANE: Oh, I'm so sorry. Yes, Alan Hanson. Sorry. I don't know Alan Dobson, but I do know Alan Hanson.

DR. HANSON: Okay. Fast reactors, I wouldn't say that I'm shying away from them. I started my career looking at fast reactors over 35 years ago. They remind me a little bit of fusion. They're always just a decade or two away from successful implementation.

I believe that in the end we will find a way to make them work. They are still not economical compared to light water reactors. They are pretty far from it. But that doesn't mean they can't be made economical.

It's a challenging technology, and it's one of those examples with regard to leapfrogging. If we're going to leapfrog, we would skip Generation-3+ thermal reactors, and utilities would be building fast reactors.

And I don't know a single utility who would touch a fast reactor anytime soon with or without subsidies.

MEMBER MacFARLANE: Why specifically is it a challenging technology?

DR. HANSON: It's a challenging technology because of the reactivity of the fuel, the nature of the coolant, the materials that need to be used to contain that coolant, and I think very important from the operations, the fact that the coolant is opaque. There are a lot of issues that need to be dealt with that are very sophisticated in order to make this technology work well.

With regard to volume reduction, you were right on a per-unit basis the increase in the heat load from the fuel goes up. However, it takes seven or eight light water reactor fuel assemblies in order to make one MOX assembly. So you've got a one-seventh reduction of the volume if you were to bury those assemblies. So you can space them seven times further apart, which easily takes care of the increased heat load on a unit basis.

You need to look at volume and you need to look at heat together. And by the way, I'm not suggesting that we bury MOX fuel. It is not the intention to do that in France. The used MOX fuel will either be used at feedstock for those fast reactors when they become available or there will be multiple recycles carried out in order to reduce the volume even further.

MEMBER MacFARLANE: Okay. The next question for Mr. Dobson.

You mentioned that there are potential problems with integrating thermal and fast reactor fuel cycles. What are they?

MR. DOBSON: It's the problem of scale, and we are making the assumption that we want to deal with all the used nuclear fuel.

MEMBER MacFARLANE: Yes. So let's hear more about that.

MR. DOBSON: Well, you've got --

MEMBER MacFARLANE: What are the problems with dealing with all that huge stockpile of very old now, used nuclear fuel?

MR. DOBSON: Well, the problem of age, that's not the challenge. The problem is, quite simply, this: that the concept is we have a large number of thermal reactors, and eventually fast reactors will be demonstrated, for the reasons that have already been spoken to, to be commercially-viable. We will get to a point where they become commercially-viable. You know, the reactor companies will develop solutions to today's problems.

So we have a large amount of LWR fuel, and we want to put that material through a fast reactor cycle. So we just need to remove the uranium, the large quantity of the bulk uranium, and separate that. And it's more economic to do that, from our analysis and information, in an aqueous system than it is in a non-aqueous pyro system.

So we propose a head-in process to take the uranium out and separate the transuranics, and provide the feedstock, the transuranic feedstock to go into the fast reactor cycle.

MEMBER MacFARLANE: Okay, great.

And finally, for Ed, in your little one-pager, or whatever, there are a couple of things I had a question on.

One, I wanted you to tell me a little bit more about, in a comparative sense, why pyro processing, in your view, is as bad as the aqueous processes.

And then, secondly, you talk about reactor concepts that can achieve high rates of internal conversion and fission without reprocessing and recycling. What are those reactor concepts?

DR. LYMAN: Thanks, Allison.

With regard to pyro processing, in particular, the notion that bulk separation of transurancis with plutonium reduces significantly the proliferation/terrorism risk associated with the fresh fuel has not been validated by those studies which indicate that most transuranics themselves are weapons-usable.

There are iterations of pyro processing where there may be self-protection, which is marginally better than current standards for a short period of time. Some of the lanthanide fission products do provide some dose, but they decay rather fast. So a number of studies have shown that the actual self-protection of the pyro processing product is really not significantly different from separated plutonium after a couple of years.

In addition, pyro processing is more challenging to safeguard than even aqueous reprocessing because of the inhomogeneity of the system and the inability to measure accurately the fissile material content in a variety of locations in the system.

With regard to your second question, we do favor exploration of systems where you may achieve higher uranium utilization without reprocessing. One is the general concept of breed-and-burn, and I think you are going to hear more about the traveling wave reactor in the next session.

These systems are complicated, and development is probably going to be difficult, but that is also true of the systems that I described before with fast reactors, thermal reactors, and repeated recycling. So I don't think the technical challenges are going to be much greater. And the ultimate objective of being able to achieve those improved fuel cycle characteristics without reprocessing is worth pursuing.

CHAIR DOMENICI: Our Co-Chairman has a question.

CHAIR PETERSON: Just to follow on with the question because, as you note, the self-protection levels of transuranic plutonium mixtures are not that high. Two parts to that question.

The first is, could you comment on the additional barriers to theft that are provided by handling materials in hot cells as opposed to, say, gloveboxes, because they are sufficiently radioactive that you need to?

And then the second thing would be a longer-term question. The same thing happens to spent fuel. That is, it is self-protecting after 60 to 80 years. Those are longer-term risks, but how do we manage those under the once-through cycle?

DR. LYMAN: To address the second question first, it is true that spent fuel self-protection is going to decay over time. And the theory is that if there is a geologic repository available that will be irretrievable on a timescale which will compensate for the reduction in self-protection, then that would be able to mitigate that particular problem.

Now, in the event we're facing where we may have above-ground storage of spent fuel for over 100 years, maybe in 300 is being discussed, that is certainly an issue. And spent fuel will have to be, the physical protection will have to increase over time to compensate for that.

With regard to the risks associated with pyro processing, if you could truly have integrated, you know, the so-called integral fast reactor where there's never any fresh fuel that's leaving this closed system, I would agree that that would confer some benefit against sub-national theft. But there is no model where that would be the only use of that material.

There would have to be additional processing and transport of materials in any realistic scenario. In that case, the concerns associated with the lack of self-protection would be more evident.

CHAIR DOMENICI: Thank you very much.

Now let's follow along where we were. Phil Sharp?

MEMBER SHARP: Thank you, Mr. Chairman.

I'm having trouble understanding this since I'm not very technically, I'm not at all technically-competent on this issue, understanding what was said earlier about the 300 to 600 years, among three of you at least. Were you telling us that, if we engaged in the right -- we have the technological possibility of reducing and burning up the foul stuff sufficiently that, then, the ultimate repository would only have to worry about a 600-year timeframe? Did I get that right or have I got that --

MR. FULLER: Let me see if I can answer that, Phil.

First off, I would like to do a correction for the panel. I think the Senator referred to me as "Dr. Fuller", and I have to admit I have not had the honor of that bestowed upon me yet. So I'm just a simple business leader, not a technical leader.

If we would like to get into a detailed technical discussion, I've got Dr. Eric Loewen with me today to support me in this discussion.

MEMBER SHARP: I don't think you need to apologize to me, by the way.

(Laughter.)

MR. FULLER: Let me give you the simple answer from my point of view. It is that in advanced recycling technology, because you have not separated out the transuranics, including plutonium, and you put them back into a fast breeder reactor, it will, in essence, burn up a majority of the energy that is in that. By doing that, you are reducing the half-life of the material left over dramatically.

So, instead of having a Yucca

Mountain that we were designing for 10,000 years for safety of storage, you can design -- you still need a repository possibly about the same size, but you're designing it for 300 to 500 years, when that waste product, the energy of that waste product starts to dramatically reduce.

And from a public point of view, I think people can get their heads around the design of a facility that's 300 to 500 years -- let's even say it's 500 years on the outside -- versus a facility that you have to design for 10,000 or more.

MEMBER SHARP: I appreciate that. That's what I thought had been said, and what I wanted to do was test that with other members of the panel, whether they accept that theory, not on the public acceptance issue, but on the question of whether technologically we can reduce the threat and contain it into, you know --

DR. HANSON: If I may, first of

all, I need to make a correction. The DOE was originally licensing Yucca Mountain to a 10,000-year standard, but, in fact, because of the NAS, they are licensing to a million-year standard, which, frankly, I don't think we're going to be able to ever convince the public we are capable of doing.

MEMBER SHARP: For good reason; this is smart on the public's side to not think any of us really know a million years from now what the situation is. Pardon me. I'm showing, I'll share my ignorances, too. Maybe there are some scientists that disagree with that.

DR. HANSON: But Jack Fuller is correct; if you remove and recycle all of the uranium and the plutonium and the minor actinides, you are left with the fission products, and now you do have a 300-to-600-year problem. However, we don't know how to do that today efficiently. We were all doing research all around the world to get to that point in time, but we can't get there today, in my view.

But just to give you an example of how one could make progress, if you take the waste and the radiation characteristics of the vitrified fission products that we put into glass canisters in France, and you watch the decay of the fission products over time, those high-level waste glass logs could go into WIPP in a relatively short period of time.

We have a repository in the United States which could take the high-level waste, based on the processes that we are implementing today. Now, again, I'm not recommending that we do this, but it is a step in the right direction. By removing the plutonium and doing thermal recycle, we reduce the problem from a million-year problem down to a 30,000-to-50,000-year problem. It's a step in the right direction. If we remove the transuranics then later, we move down to a 300-to-600-year problem. That's, I think, everybody's goal in the long-term.

MR. FULLER: One of the other comments I would like to make to the panel is, to me, this is something that in GE we call the multi-generational plan. A multi-generational plan says that you have a vision of today, a decade from today, and 50 years from today.

I think as you consider your options of what to do with the spent fuel, you've got to recognize that there is going to be a final repository needed someplace. It may be for different materials.

CHAIR DOMENICI: So there will be a repository --

MR. FULLER: There will be a need for a final repository of material someplace. It may be a much shorter timeframe than the 10,000 years.

There is a benefit in mixed oxide fuel reprocessing right now. You can get some of that energy out, and it's an interim step.

But I think the final step of thinking about how you deal with it has to be the recycling because, when you get to the recycling technology, you get 90 percent of all that energy back out of that bundle instead of wasting 90 percent right now.

So I think if you think about this as a multi-generational plan, that all of these things make sense; it's only a question of when. Then the question is, how do we shape the vision for the future to get to that plan and how do we have the staying power past various Administrations to stick with that plan?

MEMBER SHARP: I would like to get other panelists' response to that possibility.

DR. RESNIKOFF: I wanted to comment on your question. There are a lot of if's that were just mentioned. It requires a separation technology for these minor actinides which doesn't exist today. It requires a fleet of breeder reactors that will burn up some of these minor actinides.

So, in my point of view, I don't see a Hollywood ending to this whole discussion. I see continual storage at reactor sites, but hardened storage to reduce the proliferation issue and sabotage questions. That's really the way I see the future. And I don't see an ultimate ending to this story. I don't know; maybe the other panelists have a much more optimistic view.

MEMBER SHARP: I don't know if the other three panelists would like to comment on that.

DR. JACKSON: I would like to comment, just from the standpoint of we do have to deal with the legacy of fuel that we have now, and there is a need for technology to be developed to be able to reach that 300-to-600-year goal.

But beyond that, working on a separate path, looking at the very long-term, to integrate the whole fuel cycle in ways that the requirements for the back-end drive you back into the LWR cycle in the front-end, and if you can, in fact, approach some of those cycles so that you are creating fewer of those transuranics as you go forward, then the fission product 300-year cycle decay is the one that is the limiting factor.

So I still think there are two parallel tracks that we need to think very carefully about.

MEMBER SHARP: Do the two tracks together ever get you to the point of the 350 or are you telling me that we need a Yucca Mountain, no matter what, under its theoretical requirements?

DR. JACKSON: The two do. You do need an ultimate repository at some point. The characteristics of that repository are determined by what you do on these paths, either both with the legacy fuel and with the long-term cycle development.

MEMBER SHARP: But you're going to

use up that legacy fuel is the point in that?

DR. JACKSON: Right.

MEMBER SHARP: You're going to get the tracks merging into one?

DR. JACKSON: Correct.

MEMBER SHARP: Yes?

DR. LYMAN: Yes, if I may briefly, in our view, simply it is not feasible to construct the system that would achieve that kind of reduction in repository requirements cost-effectively or on a --

MEMBER SHARP: In other words, it might be technically possible, but you just doubt that we could ever build this --

DR. LYMAN: Well, I think on an engineering scale it would not be possible. I think when the panel examines, for instance, the EPRI report that I mentioned that was described to you at the Idaho Falls meeting, just taking one example, they found that with this near-perfect system, to reduce actinide inventories, that even after 1334 years, they would only have reduced the actinide inventory in the system by 95 percent relative to once-through. That 5 percent long-lived actinides is still going to be a burden that you're going to have to carry. So, I think even with a near-perfect system, you're not going to be able to achieve those kinds of unrealistic numbers.

MR. DOBSON: A lot of things have just been said about separation of actinides. In our assessment of the situation, we found that it is possible to separate the actinides, but more development work is required to confirm the separation efficiency.

But I would go back to the point that Alan Hanson made right at the outset of this set of responses. If you have recycled the fuel, and he made the point about the glass logs that are sitting in France and the United Kingdom and Japan. They contain americium and curium, the two actinides of interest. And after a few hundred years, that material would actually meet the specifications for disposal in a salt dome repository like the one in New Mexico, the Waste Isolation Pilot Plant.

So, there is a route to deal with that material, even if you were unable to achieve the separation efficiency on the americium and curium. There are other possibilities for burning the americium and curium, and they are in the report that we submitted to you.

But the point we must emphasize, there is an alternate disposal pathway if you take that. And although the separation efficiencies, it's quite correct, have not been demonstrated yet, and that feeds into the EPRI discussion, we must not let the art of the perfect beat what is possible to actually achieve.

MEMBER SHARP: Well, if I could just follow up with the two gentlemen on the end, Mr. Resnikoff and Dr. Lyman, I just wondered if they would want to comment on this theory that we could, after a couple of hundred years, take the glass logs and put them in WIPP.

CHAIR DOMENICI: I wonder, Phil, if with this question, you would let us yield a little to Susan --

MEMBER SHARP: Sure.

CHAIR DOMENICI: -- and then come back to you?

MEMBER SHARP: Sure. No, that's fine.

CHAIR DOMENICI: You're asking such great questions it's taking a lot of time.

MEMBER SHARP: I see why the Senator was so incredibly successful at keeping his constituency together.

(Laughter.)

CHAIR DOMENICI: Okay, you may proceed.

MEMBER SHARP: I just wondered if

I could just follow up that question to see if they have a comment on this claim that we could take the glass logs as they are now and simply put them in WIPP. I mean they can't do it now, but in 200 years or whenever.

CHAIR DOMENICI: In their current form? In their current form? Is that what somebody recommended?

MEMBER SHARP: But 200 years later.

DR. LYMAN: Just quickly, in my view, that's not really the right question to ask. I think probably, according to the WIPP waste acceptance criteria, you could because WIPP is a repository for plutonium, which has a very long half-life, but it is not a 300-to-600-year repository. The philosophy behind WIPP is that there's going to be essentially no migration for a long time.

So it doesn't answer the question that you originally posed, whether --

MEMBER SHARP: I'm not asking that

question. I've switched questions. This gets into your realm of we're now being more practical. We're never going to get to what these folks think. So, if we can't get there, is this a reasonable proposition?

DR. LYMAN: Well, you could probably also bury the spent fuel directly in that case because, once the heat load is reduced to the extent, you can bury in the salt formation. So it's not --

MEMBER SHARP: So, in other words, you're not challenging --

DR. LYMAN: It's an irrelevant point. We're not challenging that, but it's not relevant.

CHAIR DOMENICI: Thank you. We'll have a lot more to say about high-level waste and WIPP in terms of the process. That's where we are with friendly neighbors and people that want what they've got. That has to be taken into consideration.

Susan Eisenhower had a question.

MEMBER EISENHOWER: Well, first of all, I want to thank the panel for a very illuminating presentation. So I greatly appreciate it, and thank goodness that we have had the question-and-answer period because I'm one of these people -- and I may be the only person in this room that has not yet made up my mind on this issue. And therefore, I found the presentations actually rather frustrating, in the sense that -- to say the least.

We had four people that made basically the same declaratory statements and two people who basically made completely different, opposite declaratory statements, all declaratory statements based on facts. So, for somebody who is trying to make up his or her mind on this subject, this is extremely confusing since we seem to have a difference of opinion around the facts, and I hope that I'm not entirely correct about that, there's some nuance I'm missing.

It has occurred to me that part of

our problem here is that, just as there was some definitional question about what's economical, that we have a definitional question around tolerable risk. Since this Commission is convened to be thinking about long-term strategy on this issue, obviously, I'm saying this more as a statement to the Commission and to be on the record, but we are going to have to come up with some definition of tolerable risk and what actually constitutes reasonable economics. Because, otherwise, everybody at this panel is correct, and if everybody at this panel is correct, we are never going to be able to move forward.

So I had sort of two questions I wanted to ask to each side, just to help me clarify in my own mind how to think about some of these very different presentations.

To our two panelists here who clearly are not in favor of recycling, what do you think the strategic thinking is of other countries that are currently undertaking reprocessing? Clearly, they worry about their own personal health and security and non-proliferation. Could you give us an insight into how you think the other guy is looking at this?

And to the other four panelists, who clearly don't agree with the other two panelists -- and, oh, I'm sorry.

For the other two, could you also say something about your views about research and development? Because I sort of got the impression that you think it's hopeless. I'm curious to know whether you have any confidence in the other four panelists sitting on the other side of the table.

To the four panelists on the other side of the table, to the two who clearly don't agree with you, what points did they make, are there any points that they made that you would concede has validity and requires further investigation on our part?

Thank you.

DR. RESNIKOFF: With regard to --

MEMBER EISENHOWER: For the first two, I want to know how they thought other countries were viewing this and, also, their attitude to research and development.

And to the other side, I would like to know how they really respond to the factual questions.

I mean we could find another way to do this, but somebody has got to help at least this Commissioner understand what are irrefutable facts. You know, everybody has a right to their opinion, but they don't have a right to the facts. And we're going to have to get at this because we're going to have to make a case to the public that the assessment we're giving is based on facts. And I'm actually more confused this morning than I was before I came.

CHAIR DOMENICI: I don't know if you're that confused. There are many people in this room, and some must be more confused than you.

(Laughter.)

But, in any event, we're going to start answering that, and then that's the last question before our break. I do have a couple that I'm entitled to.

Do you want to start on your end?

DR. RESNIKOFF: Yes. Just briefly --

CHAIR DOMENICI: Sir, first, I want to tell my good friend who's second there why he was called "Dr." You have what is called a water pitcher between you and me and your sign, and it hides your name, see. So I didn't see "Jack". I saw nothing. And I thought, well, he must be a "Dr."

(Laughter.)

MR. FULLER: I appreciate the honor.

CHAIR DOMENICI: That water pitcher helped you today. You got a degree.

(Laughter.)

All right, we're going to start with you, sir.

DR. RESNIKOFF: The countries that are reprocessing don't have repositories. They have not solved the waste problem.

But I see long-term storage as a way to reduce the risk. That is to say, there is a caveat to this. We work for the State of Nevada on transportation issues. Allowing waste to remain at the repository site in safe storage reduces the transportation risk.

So, when you consider all the risks, you need to take them all into account, transportation being one of them, it does reduce the risk.

And it also reduces the risk in placing material into a repository if you reduce the heat load before you put it into the repository.

But I want to, then, reemphasize a point that Allison made, which is that when you have a large buildup of these minor actinides, it does increase the heat load in the long-term, not the short-term, not the 300-year timeframe, but in the longer timeframe. So that risk also must be taken into account.

CHAIR DOMENICI: Thank you very much.

Do you want to go right down the table, if you have an answer? We don't have to.

DR. LYMAN: Sure. On the question of other countries, I don't think there's a one-size-fits-all with regard to those countries that have chosen to reprocess. But I do know that those countries have accumulated large inventories of plutonium that is surplus, that it requires significant resources to protect against theft and, also, poses safety issues.

To a large extent, it is based on wishful thinking. It is based on the expectation that there will be a fuel cycle in the future that will be able to absorb these inventories, but the history so far is that France has accumulated 50 metric tons of plutonium in storage that it is not able to absorb into its fuel cycle. Japan has about 40 tons domestically and overseas. The United Kingdom has accumulated over 100 metric tons of plutonium.

And you have to put that in context where only 4 or 5 kilograms is enough to make a nuclear weapon. So these countries, based on highly-unrealistic expectations of what they think a fuel cycle can achieve, have I think dug themselves into a much deeper hole than the U.S. is at this point, where we do not have any significant surplus stockpiles of civil plutonium. We have the stockpiled military plutonium, which is going to cost many, many billions of dollars, taxpayer dollars, to get rid of over the next several decades.

With regard to R&D, as I said in

my testimony, we think that there's a lot of work that can be done in improving the once-through cycle, improving uranium utilization, reducing the potential need for uranium enrichment as a per-megawatt-day of electricity generated, which we also think could be a significant proliferation boon.

And we think the fast reactor camp has dominated the U.S., the DOE R&D infrastructure for too long, and they have stifled the development of other ideas. And we would like to see those ideas get more significant play in the future.

MEMBER EISENHOWER: Ed, with respect to those ideas, I mean presuming that the Department of Energy, or some other government entity, is willing to engage in research and development around some of the ideas you're interested in pursuing, are you actively against pursuing research around reprocessing or fast reactors?

DR. LYMAN: Well, I think that

there's already been, the emphasis has been, in DOE's NE fuel cycle research, the emphasis has been on reprocessing fast reactor development, and that has yielded relatively little fruit in the last several decades.

My view is that that has preoccupied or it has taken the lion's share of the attention, and therefore, has stifled consideration of once-through options. For instance, if you sat down and thought, how far can we go without reprocessing, you know, taking that out of the equation, and then exploring those options, that would provide new directions for R&D and could lead to further insights.

But I think, just to give one example, CANDU reactors, which can use natural uranium, they have some proliferation advantage in that you don't need enrichment for the fresh fuel. There are options where you can actually improve the operation and the fuel utilization of CANDUs, which has significant technical problems.

But there has not been significant work on trying to address those problems because the attention, again, has focused on reprocessing and the fast reactor development.

So, again, we would like to at least promote new directions in research by seeing how far you can go without reprocessing.

MR. DOBSON: Your question to the four people on the left of the panel was, is there anything that we found that we agree with? And that's a very difficult question to answer other than by saying no.

(Laughter.)

However, I think that there is just one small area, and that is on the question of economics. As we made in our remarks, the conditions have to be right to make a purely economic case for recycling.

And I will just make the point that in my view, in our view, it is if there is a substantial program of new build, which we believe brings great benefit to the United States, if that program occurred, then the economics do, in fact -- they are a key issue -- but they begin to look very favorable.

MR. FULLER: What I would concede to the righthand side of the table is the fact that technological innovation is tough. It's really tough to innovate. But if you don't move forward, if you don't have a vision of innovation, you move backwards.

And I think from a nation's point of view, we cannot concede ourselves to burying this material, for 300 years from now somebody else to come forward and say, look at all this good material we can use and good energy we can get out of it.

So what I would concede is technological innovation is always going to be tough. There's going to be fits and starts. But we can do it safely. We can do it right.

We can do it and protect the material at the same time.

And as I look forward, I've got the wonderful benefit to have had two small grandchildren born in the last two years. And I look at their environment in the United States 30 or 50 years from now; it will be dependent on where we go from a policy point of view. If we don't keep moving forward, and we start moving backward, our economic environment and the environment for those children 50 years from now is going to be different, and not in a good way.

So that would be my view.

DR. HANSON: Okay. To conclude things, I think Susan's looking for perfection if she expects to get a complete consensus even on the facts.

MEMBER EISENHOWER: No, I never expect perfection.

(Laughter.)

DR. HANSON: Okay, good, because I

will quote that well-known philosopher Pogo, who said that, "I'll pit my facts against your facts any day."

(Laughter.)

And I think that's a little bit of what you're seeing here.

But I do have some areas of agreement, and I wouldn't even call them concessions. You know, there are some good points that are being made by everyone here at the table.

Here's where I agree with what we're hearing from the far end of the table: fast reactors are challenging, and they are not ready for primetime. We may differ, then, on how long it takes to get them to primetime.

They suggest that plutonium is dangerous and we need to protect it, and I certainly agree with that. It's a dual-use material. We need to do something with it.

The difference in opinion, however, is that I think it is sufficiently dangerous, and also useful, that we ought to burn it instead of just waiting for it to decay.

And that ties into the third issue, and that is, I really do agree with the intergenerational equity. And I don't have any grandchildren yet. I hope to in the future. I worry about those grandchildren. I worry about my children, for that matter.

The suggestion that we put used fuel into storage casks and leave it there for centuries is not intergenerationally equitable. It absolutely is not.

First of all, we're not dealing with the issue of waste. But even more importantly, we are not dealing with the issue of plutonium management.

As we have heard, over the next couple of centuries, the self-protecting nature of that fuel is going to go away. So what we are doing is we are leaving not only the waste problem to our grandchildren, we're leaving a proliferation problem to them. And it is not solved by putting it into the repository because, if you put the plutonium in there, you have to safeguard that repository forever. And I think that's a dumb thing to do, even if we could convince the public that we are going to be able to do that.

So focus on that intergenerational issue. We agree that there is an issue. I think everybody here agrees. We just have different solutions for how we go about solving it.

CHAIR DOMENICI: All right. Are you last?

DR. JACKSON: I would only add that it is an intergenerational issue, but it's not a burden; it's an opportunity. And there is energy and there is benefit in the used fuel. So the opportunity is to determine what policies need to be in place and what technologies need to be developed to utilize that.

I don't have grandchildren. I have teenaged children who constantly tell me, "Don't make the decision for me. Let me participate in that decision." So being safe until there are technologies that can utilize some of those spent fuels is important.

I would also agree with the other end of the table, if you will, on the issue that the long-term benefits of pursuing an additional set of strategies and policies that link together all portions of the fuel cycle really aren't fully understood.

So, until you can fully understand those benefits and risks, and do that tradeoff in the calculus, you don't know the set of opportunities that you are choosing or closing off. So I think that we do need to continue to integrate our issues.

The other thing that I will say is, having a difference of opinion is really powerful because it does improve standards and it does improve design and long-term operability.

CHAIR DOMENICI: All right, I understand that my friend has a question. Can I have mine first, and then get an observation, and then you'll wind this session up?

First of all, I want to tell you it's always a privilege to work with you on Subcommittees or Committees, and this one will be no exception. It's a very challenging Subcommittee, and you'll be right there helping us, I'm sure.

Let me make an observation or two here with you all.

First, somebody commented about whether nuclear power was competitive in the United States. And I guess it was in reference to your observations where you laid before us the costs.

The answer to whether it was economic now or not was played upon by something that happened. It was very unexpected. This guy is a Senator for 36 years, and until three years ago, I spent on the energy side 10 percent of every year, and in one year 15 or 20 percent, on the issue of natural gas because we couldn't get it out of the ground for 25 years of my 36 because it was under federal judge order that it was interstate-regulated and the Interstate Commerce Commission set the price. So it was a regulated commodity, and we found little or none of it. We broke that and said we're going to do a little bit of it, and eventually we said it's open to be drilled, subject to state law on conservation.

During that period of time, on another side, some research was taking place with reference to drilling, so that you could drill in and then drill sideways. So you could put on the bit of a drill something that, once you got it in there, would explode and push water out at a very high volume. And guess what? It pushed the natural gas out with it.

So here came the greatest nation on Earth suffering for energy, and by an accident of intervention of scientists who were working on drills to drill better holes to get natural gas and crude oil out of the ground, they found that all over America there was a source of energy called natural gas that we had not even looked for because we said it's there, but we can't get it.

So, through research and continued intervention by people who wanted to make money -- I hate to say it; they were all capitalists -- they went out there and found a whole new source. And all of a sudden, the great source of energy called nuclear and nuclear power plants became subject to $3.25 natural gas, which used to be $15 a barrel, $15 a BTU. And during my last two or three years in the Senate, it was $12 to $13. It was so high that Dow Chemical was going broke, moving out of this country because they could not afford to survive on natural gas at that price.

Well, who would have looked at the price of Dow's stock when we found that natural gas came tumbling down? And who should have invested and made money? Everybody that knew what I know should have put all their money in Dow stock because it went up sixfold in three months, from $4 or $5 to $20 or $30. Why? Because this product that was found by accident, intervention of science, not really accident -- they were looking for better ways -- found a way to give us this asset.

Now I'm telling you I'm beginning to learn that there are a lot of people that think we ought to put this high-level waste away permanently and say that's the end of it. And we're having a very strange happening of new events. Because, let me tell you, we are almost prepared to tell the American people, and I think that everybody would vote for this, that we have an interim storage solution that is viable and we should build interim storage facilities, and we should also have onsite. Many of the sites that have dry casks should remain as temporary sites for the disposal of spent fuel.

Now, in this, it's clear to me that you can find a way to dispose of it, some of it, to save it for future use in some way. And you have to ask your question, what are you trying to do with the waste? And that's what I think we have to answer. Are we just trying to get rid of it, so it is no longer a hazard? Are we trying to save it because it has energy in it? And can we at some time decide that we don't need the energy? We would have to admit today uranium is pretty cheap, and you won't compete with it with the use of temporary -- you won't compete with it with recycling. That won't work. Recycling won't work for the time-being.

So I'm not sure that this Commission was put in play, Susan Eisenhower, to just answer the question of we can put it away in salt, in a permanent fashion, wash our hands of it, and it's over with. Because we have to ask ourselves the question, do we want to use it someday? It's got 97-98 percent of the energy it started with still in it.

Right now, the Japanese are looking at research -- you should all know that, and we should get some testimony on it -- on finding uranium in sea water. If they succeed, there's going to be another giant source of uranium. I don't know if you all know that. It's gigantic, and it could be.

Where here again, it is just we've got to have something that's flexible enough to handle these situations, but, clearly, it is not the simple thing of just putting it all away in salt or other places forever. It has got too many claims on it for us to do that.

Now, having said that, I shouldn't

have said that, but I did.

(Laughter.)

And I feel very good about it because we're still on time.

(Laughter.)

Okay? Doctor, do you want to proceed?

MEMBER MESERVE: Thank you, Senator.

In contrast to your rather global and profound comments, I'm going to ask a much more particular one that's just a followup on some of the testimony from Dr. Hanson.

As I understood your testimony, the proposal that you had suggested for us is to take existing light water reactor fuel, recycle it one time as MOX, and that then the MOX fuel, after it has been burned once in the reactor, would then be stored for possible eventual use. And I believe that is the model that the French are following in France.

I guess the question I have is

that, given the abundance of uranium and the fact that we can store the light water reactor fuel as it is safely and securely for as long as we want, and it's not economical, as we have discussed, to do the reprocessing for MOX, why be bothered with that step? Why don't we just hold the fuel and wait and see what we should do with it? And perhaps R&D, as we have discussed, might provide some other options for us that could even be foreclosed by having proceeded with the interim step of generating MOX fuel.

DR. HANSON: There are a variety of answers to this. But, first, I have to disagree, as I did earlier, with regard to economical. It can be economical. It is economical. Or, otherwise, people wouldn't be doing it. There is, at most, a small penalty that is being paid by the countries who are deciding to do recycling.

One of the reasons to get started is that you don't make technological progress only in the laboratory. You need to reduce things to practice in order to find out whether they are going to work on a commercial scale. And I can give you lots of examples of technologies that worked in the lab and never worked when you got them to the industrial scale. So you need to do that.

You need to have a workforce that is knowledgeable and capable of dealing with the technologies that you're working on. There are a lot of white-haired people in this room; I'm one of them. And you're watching the knowledge about aqueous processing and separations chemistry and radiochemistry disappear in this country. That is one of the reasons that we are running behind the rest of the world, where they have continued to work on this during the decades that we sat on our hands and expected everybody else to stop.

I think, very importantly, I'm going to come back to plutonium management. My view remains that plutonium is something that we will eventually have to dispose of. We will not be able to leave it on the surface. We are not going to be able to put it in the repository. We are going to need to burn it up. So, if we get rid of 30 percent of it now, it is a step in the right direction.

I can tell you that our primary customer, ADF, in France, will not allow us to burn it a second or third time because they want to preserve the plutonium that is in there for the fast reactors which they expect to come. Because you need a significant plutonium inventory to start up those fast reactors.

But by doing the once-through recycle, we start down the path. We remove some of the plutonium. We denature the rest of it. And for those who are big fans of self-protection, we make it more self-protecting and we reduce the volume down by a factor of one-seventh. We've got one-seventh the number of assemblies to store on the surface of the Earth until we do something with them. That's a step in the right direction.

Do we have to do it? No. I think it makes good sense; other people don't. I think it ought to be an action, and that's where I would leave things off. I think what's important for me is that this Commission does not prematurely close off options. We don't have to make all of the final decisions today. We just need to start down the right path.

Leave it to the federal corporation to make the decision on when and how to do recycling. You don't have to decide that as a panel. And I think that would be a perfectly acceptable outcome.

CHAIR DOMENICI: The schedule says that we're about eight minutes late, but we are going to start this next meeting at what time?

MR. FRAZIER: We are 15 late.
CHAIR DOMENICI: All right.
MR. FRAZIER: Let's just take a 10-minute break?
CHAIR DOMENICI: A 10-minute break. Thank you.
(Whereupon, the above-entitled matter went off the record at 10:30 a.m. and resumed at 10:43 a.m.)
MR. FRAZIER: Okay. Now I am serious. We are going to get started. Come on in, take a seat.
We are missing Chris Mowry. All right, we're going to start without him.
Per, are you going to start?
CHAIR PETERSON: Yes. I would like to recognize Senator Domenici.
CHAIR DOMENICI: Yes. It's time for us to get started. Mr. Chairman, I will be right back, but I have to excuse myself for a moment.
CHAIR PETERSON: Okay. We'll get

started. Thank you.

Thank you. We are starting the second panel of today's session.

Today this is a continuation from the first panel, "Opportunities in Reactor and Fuel Cycle Technologies".

Okay, if we could have things quieted down in here? Okay.

As with the prior panel, the Commission asked the panelists to consider the two following questions:

The first, from your perspective, are there technology options, including alternatives to the once-through fuel cycle, that hold significant potential to influence the way in which used fuel is stored and disposed?

And two, are there federal actions that could facilitate commercial efforts to develop and deploy these technology options while meeting economic, safety, environmental protection, security, and non-proliferation goals?

As with the previous panel, we would like to remind panelists that they are to keep their presentations to 10 minutes or less, and that the remainder of the panel time will be spent on questions, as you saw with the last panel, and discussion with the Subcommittee members.

So let me introduce our first panelist, Dr. John Parmentola, Senior Vice President of Energy and Electromagnetic Systems at General Atomics.

Doctor?

DR. PARMENTOLA: Well, thank you very much. I would like to thank the Commission and also this Subcommittee for giving me an opportunity to talk about a new reactor concept that we have been working on at General Atomics for the last two years.

The motivation behind this reactor involves three major issues.

One was, could we drive down the

economics of nuclear, making it more competitive in the marketplace?

The second, could we turn used nuclear fuel into a resource and extract the energy out of it efficiently?

And three, could we do it in a way in which we increase proliferation resistance?

What I hope to convince you of today is that there is a potential path toward trying to solve all of these problems simultaneously. However, I will say right now, we don't have all the answers to trying to realize this, and it will require research in order to be able to explore this.

Of course, when we did this two years ago, we weren't aware of the formation of this Commission and also its charter. And in fact, we were pleased to see that, in fact, the memorandum that led to the creation of this Committee was trying to address similar issues that we at General Atomics are trying to address.

There are, from our point of view, five key national issues that need to be addressed in nuclear. One is what to do about the used nuclear fuel; economics, trying to make nuclear energy more cost-competitive; trying to address the issue of non-proliferation or, another way of saying it, could we increase proliferation resistance in the way in which we deal with the used nuclear fuel, closing the fuel cycle, et cetera, and energy security which is constantly coming up and giving us a lot of problems in terms of trying to address it.

And the fifth, and I don't mean this to be the least important, the human dimension. We can't create the future without people and we can't develop new concepts and new technologies without encouraging people with eager minds to address the issues that we face with nuclear.

So the goals of Energy Multiplier Module, which is this new reactor concept, are it is a modular, high-temperature gas reactor. It's a fast reactor.

What follows from this is it burns, consumes used nuclear fuel and reduces the used nuclear fuel inventory, and it transmutes what are generally called the heavy metals into fission products, and I'll discuss that in a moment.

It is a modular reactor and it's a high-temperature gas reactor. Being high temperature, it has greater efficiency than existing reactors. I will talk about that in a moment. It is modular and, as such, we envision this reactor to be built in factories using manufacturing techniques, assembled into large parts, and shipped on the U.S. highway system to be assembled at a reactor site.

As far as proliferation is concerned, this reactor reduces the dependence on uranium enrichment and there is one scenario where, in fact, it eliminates it. It does not require conventional fuel reprocessing in order to be able to close the fuel cycle.

As far as energy security is concerned, I said this is a high-temperature gas reactor. As such, it does not require water for cooling. Therefore, it has significant advantages in terms of siting flexibility. As such, it could contribute to a future where we would be pursuing electrification to provide electricity to a broader demand across the country.

It's also a high-temperature gas reactor. So, in addition to efficient electricity production, it also can provide process heat application, which can reduce our dependence on natural gas in industries that use process heat. As such, it will reduce CO2 emissions.

Now in order to realize this, it requires research. There are major research challenges that need to be addressed in order to do this. We believe these research challenges will attract eager minds to try to address these issues.

As I said, this is a high-temperature gas reactor. It is a 500-megawatt thermal reactor, 240-megawatt electric. That implies it has a 47 percent efficiency. It achieves that because of both the high temperature as well as an advanced high-speed gas turbine, which you see off to the right.

It operates at 850 degrees centigrade. It can utilize or burn either depleted uranium or used nuclear fuel and, again, without conventional reprocessing. It's passively safe. It is not inherently safe. And as such, it's comparable in its safety to existing light water reactors. It's underground-sited.

As I said, it is a modular reactor. We envision this as being manufactured, in fact, using replacement part manufacturing and supply chain management, and shipped by commercial trucks in large parts and assembled on site.

The reactor, as designed, burns for 30 years without refueling or reshuffling of the fuel.

Why are we interested in used nuclear fuel? Well, if you look across the United States, as others pointed out, there's 60,000 tons of used nuclear fuel, but there's also 700,000 tons of depleted uranium.

Theoretically, the amount of energy that is contained in that material, both of those, is equal to 9 trillion barrels of oil, which is four times the known reserves of oil and twice that of the known reserves of coal.

I will also point out both oil and coal are being depleted. The reserves are expected to last of oil 40 years, that of coal 128 years, while the used nuclear fuel and depleted uranium are growing. So that is a resource that is growing, and if you think about it, the various ways of thinking about it, it is equal in value to about 50 times the national debt.

This gives you an idea of what the fuel cycle looks like for this reactor. On the left, you see the spent fuel.

There are two components to this reactor. There's an LEU starter, which involves 12 percent enriched uranium. In addition to that, you can either load the reactor with used nuclear fuel or depleted uranium, which makes up the balance of the core.

As this reactor burns for 30 years, the neutron economy remains abundant, and after 30 years, the reactivity goes down because of fission products, as everybody would guess.

The energy content of the discharge is substantial at the end of this. And of course, if you could remove the fission products, there's enough energy in that discharge to power another reactor.

And in fact, what we envision is GA, General Atomics, has a proprietary technology that has been demonstrated at a prototype level -- it's called Archimedes -- that can remove light elements from heavy elements, although it still needs to be explored and studied to make sure that, in fact, it can do what we think it can do.

So you remove these fission products after 30 years, and you can take that discharge, refabricate it into fuel elements, and start the next generation. Of course, at this point you don't need enrichment anymore, and you can continue this process. We have studied this process through seven cycles, tracking fission products, 2,000 of them, to see if there's any way in which it stops. So far, we can't find a way in which it stops.

I said that you could start this without enrichment. Instead of using low-enriched uranium, you can use WIPP surplus plutonium and start this reactor, and it will go on forever.

If you look at a particular quantity called fuel utilization, it gives you an idea of the effectiveness of a reactor to extract energy. What it is is you take the mined uranium, and then you take the amount of that uranium after enrichment that's fissions. That gives you the fuel utilization for light water reactors. It's 0.5 percent.

For EM-squared, it starts out at twice that because you load the core with the used nuclear fuel. We don't consider that to be waste. That's actually fuel. And what it does is it grows with time along the abscissa. What you're looking at is EM-squared cycles. Those are 30-year cycles, and it grows as a function of time because the fuel is being recycled and you're extracting efficiently the energy out of it.

If you look at the waste, you see that light water reactors, as far as volume is concerned, produce much more waste than EM-squared. EM-squared is fission products. You will see that light water reactors produce 12,000 tons. EM-squared produces 450 tons of fission products as a function of time, and the scale there is 400 years.

This reactor has been peer-reviewed by the U.S. Department of Energy. Three labs participated in it. There's a 134-page report that outlines the challenges associated with realizing this reactor. We have responded to it, and we've also developed a development plan as well as a risk reduction plan.

So my recommendations to this Subcommittee are the federal government realize reactors like EM-squared. The federal government should adopt a policy that encourages new concepts that concurrently address the issues that I described. They have to concurrently address them in order for us to be able, in our opinion, to make progress.

And the federal government should support research that is required to address the major challenges involving concepts like this to move forward in the future.

Thank you.

CHAIR PETERSON: Thank you.

In fact, the EM-2 can operate for 30 years without any fuel reshuffling. Unfortunately, we've actually sort of reshuffled our speakers in a far shorter period of time than that. So I'll go through the order of presentations because I think we'll have Dr. Lorenzini next, then Chris Mowry, then, actually, Dr. Hargraves and Cochran and Rothwell. Or is there any preference here?

Okay. Why don't we stick with the original agenda, which would be Dr. Lorenzini? Okay. Very good. Thanks.

DR. LORENZINI: I am Paul Lorenzini. I am the CEO of NuScale Power.

We are singularly focused on the

development of a modular, scalable light water reactor. It's a technology that grew out of test work at Oregon State University on the AP600 and the AP1000, focused largely on how natural circulation works in a passive system, and then a DOE program about 10 years ago that ultimately led to this design.

In very simple terms, it is modular in two ways. It is modular, first of all, in the sense that the entire reactor plus the containment is built in a factory and delivered to the site.

So you can see here the reactor is under water. The containment is 65 feet by 15 feet, and that is sized in an envelope, so that it can be shipped. Inside the containment there's a pressure vessel and then there's a nuclear reactor at the very bottom in red.

Cooled by natural circulation. So it is a very simple design. It is based on established technologies. Natural circulation gives us reliability. It gives us safety. It gives us economics. We eliminate failure modes. We eliminate equipment. We eliminate large-break LOCA phenomena. The safety analysis is very, very simple.

It is below grade in a pool of water. So we get a very elegant system for removing decayed heat under various scenarios, and the containment being in a pool of water inside a building, we have added barriers for the release of anything to the environment.

So it is modular in a sense that it is factory-manufactured. It is also modular in the sense that we build a large building with a pool of water in it, and then we introduce new modules as the desire for additional generation grows. So our base design would have 12 modules in it to produce 540 megawatts, but we don't have to put them all in at once.

So you can see here this is half of the building, and you can see six modules.

So the idea is that you add a module as the desired need for capacity grows, so it's modular in the sense of how you expand it as well as how you do the factory manufacturing.

In terms of the fuel cycle, the waste, the spent fuel, is stored in a rather conventional way. It's to the right; it's on this diagram.

It's standard PWR fuel, less than 5 percent enrichment, and the concept here is that we would store the spent fuel for 10 years, and then we would take the spent fuel out of pools of water and put it into dry cask storage. So it is a very conventional approach to the fuel cycle.

The one question that we have been asked is, how would thorium work in this plant? And we actually had some conversations with some thorium people, and we sort of had a nice conversation with each other saying, gee, we sort of match in terms of what we contribute to the long-term picture.

The attractiveness of thorium is that it reduces the inventory of long-lived materials. It is more proliferation-resistant than a conventional fuel cycle, and it has got huge amounts of resources compared to uranium.

And so we looked at it. I don't pretend to be a thorium expert, but we did conclude that you could put a thorium core in this plant. We also concluded there wasn't anything special about our plant that made it more attractive for thorium. Other plants that are light water could use thorium as well.

When we looked at putting thorium fuel, we would need to have a fuel design. We know the thorium as a fuel cycle works. It was put in Shippingport, and it ran for five years. So we know from that that you can design a thorium core for a pressurized water reactor.

There are some obvious fuel development issues. There's infrastructure issues. There's issues with regard to what the industry needs to do to be ready for it.

So there's a lot of roadway between here and actually introducing the commercial thorium fuel cycle. But from our perspective, it was important for us to know that we're receptive to that, if it can be done.

So that concludes my remarks, and I'm, obviously, available for questions.

CHAIR PETERSON: Thank you.

Next, I would like to ask Mr. Christopher Mowry, President of B&W, for your remarks as well. Thank you.

MR. MOWRY: Thank you, Mr. Chairman. I appreciate the opportunity to be part of this panel today.

My prepared remarks will provide perhaps a slightly additional or different perspective on the matter.

By way of background, the Babcock and Wilcox Company has a rich legacy of innovating energy solutions. We grew our business over the past 140 years by developing and commercializing practical solutions to the evolving challenges of the power industry. B&W has more than 50 years of continuous nuclear engineering and manufacturing experience. Seven of the large nuclear power plants operating in the U.S. today have been designed, manufactured, and installed by B&W. Many other operating reactors incorporate our nuclear steam supply components.

Today we provide customers with nuclear manufacturing and nuclear-related services for more than 17 facilities across North America, including facilities in Indiana, Ohio, Virginia, Tennessee, and Cambridge in Ontario, Canada.

We're the only American manufacturer accredited and capable of producing large N-stamped components for commercial nuclear power plants. We have fabricated more than 1100 large nuclear steam supply system components and pressure vessels, including more than 300 nuclear steam generators. We employ directly and through our joint venture companies approximately 12,000 U.S. nuclear professionals.

About three years ago, B&W began evaluating the shifting nuclear landscape. The potential for climate change legislation, the need for increased energy independence, constraints on the nuclear supply chain, increasingly restrictive capital markets, growing concerns about water rights and transmission capacity, and now a renewed focus on nuclear fuel management are pushing the industry to innovate new approaches to nuclear energy. And as Dr. Lorenzini mentioned, small modular reactors do offer significant potential to begin addressing these challenges in more a practical and affordable manner.

We have drawn upon the experience and expertise of electric utilities themselves to help us define the type of SMR technology best suited to meet their near-term needs. Their guidance has helped us recognize that many utilities are not comfortable financing large gigawatt-size nuclear power projects. For example, some smaller electric cooperatives which have historically been unable to include nuclear power plants in their own generation portfolios due to size and cost now view SMRs as a realistic solution. And larger utilities see significant value in small reactors, particularly in providing a more incremental approach to project financing and to meeting projections of more modest system load growth.

In the near-term, our utilities' customers want a smaller reactor that uses proven light water nuclear technology that can lever their substantial investment in existing nuclear infrastructure and that can draw upon the well-established conventional nuclear fuel supply chain.

We believe the broader adoption of

nuclear power as a reliable, proven, carbon-free energy source depends on an incremental approach to innovation in nuclear reactor technology and the nuclear fuel cycle.

In response to this range of emerging needs, we have developed the B&W mPower reactor. It's a scalable, modular, advanced light water reactor system that we believe can be certified, manufactured, and operated within today's existing regulatory framework, domestic industrial supply chain, and utility operational infrastructure.

The B&W mPower reactor, whose condenser is designed to be air-cooled to address water resource concerns, has the capacity to match utility requirements in 125-megawatt increments while delivering a 4.5-year operating cycle between refueling outages.

The B&W mPower reactor system is also located in a secure underground containment structure, which includes a spent fuel pool capable of holding the plant's 60-year design life of the used fuel. While the Blue Ribbon Commission and the nation identify an acceptable long-term disposition path for used nuclear fuel, the B&W mPower design provides for interim underground storage of used fuel.

The reactor design is also sufficiently flexible to accommodate a future transition and integration with other longer-term components of a more closed or modified open nuclear fuel cycle.

There are many companies currently pursuing the development of small reactors, based on a range of designs from light water technology to more long-term Generation-4 concepts. The B&W mPower design is focused on providing the nuclear industry with a low-risk, near-term, evolutionary light water solution. This means that we are building on the successes of our nation's current light water reactor fleet to make conservative, measured advances in the application of nuclear power.

Today's light water reactor technology offers exceptional plant safety and operational performance. Public support for nuclear power is generally strong, and comfort with and acceptance of light water technology is exceptional.

The importance of these factors in defining a realistic path forward for our nation's nuclear industry should not be underestimated. As our nation looks to nuclear power as a near-term, practical means to address climate change and energy security concerns, we must rely on technology that will be accepted in our communities and technology that builds incrementally on our industry's long and valuable operational experience.

Light water reactor technology is ready now. The B&W mPower reactor draws on this proven technology to offer a scalable option for better deployment economics. In the near-term and mid-term, we expect that nuclear utilities will remain committed to light water reactor technology.

In the longer-term, advanced fuel may be adopted carefully into the operating fleet to provide the next incremental advance in nuclear power efficiency and economics. Further in the future, the industry may transition to Generation-4 reactors and their associated fuel technologies when they are sufficiently mature and proven.

However, in an industry in which safety, reliability, public acceptance, and economics are the critical success factors, progress will surely be methodical, incremental, and measured. This imperative for evolutionary changes in nuclear fuel technology must also be recognized as we develop a new path forward.

We believe that the federal government should actively support near-term light water SMR deployment. The Department of

Energy has recognized the promise of SMRs in their nuclear energy road map, and this program must be funded and supported in a meaningful way.

An effective public/private partnership is critical to help reduce risks and accelerate deployment of this new technology, and a successful cost-sharing program should encompass all deployment and development activities necessary to programmatically address first-mover adoption of this technology.

We, as a nation, should plan for long-term accommodation of light water reactor fuel use by the nuclear industry. Generation-4 technologies do offer some appealing potential advantages with respect to used fuel disposition and should, therefore, be pursued to possibly compliment a light water reactor-based fleet. However, this, by definition, is a long-term goal.

In the near-term, nuclear

utilities, the financial community, the NRC, and the American public will only be comfortable with light water reactor technologies, including fuel, that have a long and proven history of successful and safe operation in the United States.

If we are to take advantage of nuclear power's benefits, we must plan to manage used nuclear fuel in a way that acknowledges light water reactor and fuel technology as the foundation of our nation's commercial nuclear power industry for the next several decades.

I would like to close by discussing utility interest in SMRs. For example, the mPower Industry Consortium currently includes 14 utilities, including TVA and First Energy, among others. These companies are leading the market for light water SMRs, and together with the Department of Energy, have shaped a road map for industry's adoption of this new technology.

We need to support the utility industry and the DOE in their efforts to help our nation develop a practical, evolutionary approach to nuclear power.

Thank you.

CHAIR PETERSON: Thank you, Mr. Mowry. I appreciate very much your comments.

Our next speaker will be Dr. Bob Hargraves, please.

DR. HARGRAVES: Aim High is a project with lofty goals. Global warming is a serious threat to our civilization. Another serious threat, world population growing to 9 billion people. Already, competition for resources such as food and energy has depleted fisheries and led to wars.

This scatterplot relates income to birth rates. The data for 84 nations are taken from the CIA World Fact Book. To the right, you see the low GDP per capita for countries with high numbers of children per woman.

Population scientists observe that birth rates less than about 2.3 children per woman are less than the population replacement rates. To the left of this line are the U.S. OECD and other nations with high incomes and low birth rates.

A prosperity level of about $7500 per capita per year distinguishes those nations with stable population replacement. Prosperity enables women to reduce labors of subsistence living, freeing them for education, work, independence, and choices about reproduction.

This scatterplot, also from the CIA data, relates income to energy, specifically electrical energy. Electrical energy is important for water, sanitation, food, heating, cooling, lighting, transportation, communications, manufacturing, and business. It takes about 2,000-kilowatt hours per year per capita, which is one-sixth of the U.S. usage, to achieve the $7500 level of prosperity that leads to stable population replacement.

Developing nations want energy to improve their prosperity. DOE projects that they will burn coal and emit more CO_2, making global warming worse.

Carbon taxes such as cap-and-trade are not accepted here in the U.S., and certainly not in the developing nations, who will not forego the advantage they perceive OECD nations had from burning fossil fuels. An alternative is to undercut coal power economics with nuclear energy cheaper than coal.

In the Cold War, Oak Ridge scientists conceived the molten salt reactor to be a compact, 200-megawatt heat source to power jet engines of bombers that could circle the Soviet Union without refueling. The first molten salt reactor proved the concept, and the fireball aircraft reactor was designed, but not built because ICBMs obsoleted the bombers.

Alvin Weinberg foresaw today's energy and atmospheric CO2 crises. He directed Oak Ridge to design and test another successful molten salt reactor experiment. It was tested with U-233, intended to be made from thorium.

Nuclear fission of U-233 takes place in the central core of a liquid fluoride thorium reactor. Some released neutrons continue the chain reaction, and some pass into the thorium blanket surrounding the core, converting thorium to U-233.

The uranium separator on the left sends thorium back to the blanket and U-233 to the core to replace that which was consumed. Fission product waste is similarly separated. Heat from fission in core is exchanged with a salt that heats the gas that runs the turbine generator.

Using thorium for fuel is one key concept. Another idea is the liquid fuel form. Uranium and thorium are dissolved in molten salts of lithium and beryllium. The liquid's high-heat capacity enables high temperatures, efficiency, and compactness. Chemical processing takes place in continuous streams.

The LFTR is started up with a fissile material, but none is transferred in or out thereafter. Thorium is inexhaustible, unlike uranium.

Once fission products decay, the long-lived radiotoxic actinide waste from LFTR are orders of magnitude less than from today's power reactors.

LFTR may make energy cheaper than from coal at a capital cost near $2 a watt. One indication is that five independent, historical cost estimates center on $1.98 per watt.

Another reason is that the LFTR needs no costly 160-atmosphere pressure vessel and containment dome. LFTR is small. The workman in the center of the AP1000 is about the same size as the fireball molten salt reactor designed for flight.

Intrinsic safety reduces the need for costly defense-in-depth. There are no pressurized radioactive materials to contain. The fuel is already melted down. Loss of power drains fuel to safe dump tanks.

The high-heat capacity of molten salt allows a compact core and high temperature. The high temperature enables power conversion efficiencies up to 50 percent, halving today's water-cooling requirements or enabling air cooling.

Factory production cuts costs. Boeing Aircraft produces similar cost units with similar concerns about materials, quality, and life safety. Factory-produced reactors will benefit from the learning curve expected to reduce costs about 10 percent for every doubling of units produced.

I recommend a specific project to

develop LFTR in five years for approximately $1 billion, as the Gen-4 International Forum suggests. Then provide to the nuclear industry all the R&D knowledge and encourage factory production and competition.

What would be the benefit of installing a 100-megawatt unit each day? If LFTRs replace coal power plants, 10 million tons of worldwide CO2 emissions will be zeroed out in 38 years.

A high-temperature LFTR allows efficient dissociation of water to make hydrogen, which is a feedstock to synthesize fuels. We can recycle some carbon from coal plants to synthesize gasoline and diesel fuel substitutes or make ammonia for non-carbon fuel or fertilizer.

Providing the developing nations with safe, affordable electric power can increase their prosperity to allow lifestyles that include lower birth rates, stabilizing world population.

But advanced nuclear fission R&D funding has dropped, and there is none for LFTR. Compared to the $16 billion spent on liquid metal fast breeder reactors, DOE will spend $103 million on the prolonged, high-temperature gas reactor development. The advanced fuel cycles budget has no money for closed fuel cycles nor for liquid fuels.

A specific LFTR project would have specific results: cut 10 billion tons of CO2 emissions by 2058, avoid carbon taxes, improve the developing world prosperity and check population growth, avoid weapons proliferation by obviating the need for uranium enrichment plants, reduce radiotoxic waste and consume world fissile material stocks, and use inexhaustible thorium fuel available to all nations.

Thank you.

CHAIR PETERSON: Thank you, Dr. Hargraves.

Our next speaker is Dr. Thomas

Cochran from the Natural Resources Defense Council.

Tom?

DR. COCHRAN: Chairmen and Commissioners, thank you for this opportunity.

With apologies to Commissioner Eisenhower, I'm going to start with an opinion rather than a fact to illustrate a point that I will get to later. But closer to facts are slides shown at Phil Sharp's Resources for the Future Program by one of your other Commissioners, John Rowe, which he used to argue why he is not prepared to build a new nuclear plant today, because the capital costs are too high.

So my point is that new reactor unit costs and the cost per kilowatt are both too high for new nuclear to be competitive in the United States. You will see some new plants, but not a significant number beyond what is heavily subsidized by the government. On the other hand, nuclear fuel and O&M costs are low and, in my opinion, will remain so for the foreseeable future.

And my point is that DOE's nuclear energy R&D program is principally focused on the back-end of the fuel cycle and on subsidizing new reactor licensing and construction, and both of these are misplaced priorities.

Now when I got in this business around 1971, the AEC had written some cost/benefit analyses and was saying that capital costs of the light water reactor were on the order of $150 a kilowatt and would be coming down to a learning curve. And that's probably in constant dollars in the range of $700 a kilowatt today. So the capital costs have gone up by roughly a factor of 10.

On the other hand, since 1944, when Alvin Weinberg and Fermi and Szilard and others, Wigner, decided to light atomic cities with nuclear power, they thought uranium was scarce and they opted to go for a breeder reactor program. And as it turns out, that, too, was a fundamental error in judgment. It was true at the time because all the uranium was going to weapons, but it turns out uranium is much more plentiful and the cost of uranium long-term, discounting a couple of spikes, in constant dollars, the fuel costs have gone down or stayed fairly constant for the last 40 years or so.

Yet, our R&D program is based on research on more ways to increase the cost of the fuel rather than on ways to reduce the cost of the reactors, the federal research, not the industry research.

So what should the government focus be? First of all, in my view, it should be on improving safeguards of the nuclear fuel cycle because that's where the problem is, on the fuel cycle side, and getting the repository program back on track.

The industry focus, and it's certainly the focus of the gentleman on this panel who has spoken just prior to me, is to try to reduce the cost, the reactor cost and the unit cost.

Now what is the government role here? I think the government role is to engage in educating new, young nuclear scientists at the universities and getting engaged in fundamental science research that has applicability not only to new nuclear, but also other energy technologies.

Commissioner Peterson made an argument for looking at novel ways or new ways or different ways of lowering the cost of construction, the cost of reinforced concrete. There are other examples, and some examples that DOE is engaging in in research today.

I don't think the government should be subsidizing the construction costs of new nuclear power plants. This is a mature industry, and there will be many people coming with ideas for new reactor designs, and they can certainly put together consortia and build these, if they think there's an economic case, without coming to the federal trough to get fed.

I'm pleased that NuStart has not approached the government. NuStart, probably with its collection of some 10 utilities and energy companies as well as EDF, Electricite de France, and GE I believe or Westinghouse, or whoever, probably has more assets than the Department of Energy at its disposal. So they certainly don't need government assistance to subsidize a good idea.

I want to say something about fast reactors because we had some discussion of that by the earlier panel. I agree most closely, I guess, with Alan Hanson on his assessment of fast reactors.

Again, we got into this business in 1944; globally, have spent probably on the order of $100 billion trying to develop liquid metal fast reactors and other fast reactors, but primarily sodium-cooled. These programs have been universal failures, I think primarily because of proliferation, the higher capital costs of these reactors relative to light water reactors, which is why you see one commercial-size fast reactor globally and 440 or so thermal reactors globally. They are not economical, and, also, they have shown historically poor reliability. I helped co-author a report on the history and status of fast reactors that I shared with you previously.

So I don't believe fast reactors will contribute to reducing the repository burden by burning actinides, primarily because it would require a shift to where some one-third of your fleet is fast reactors, and it simply is not going to happen because of the economics.

The fast reactors have an additional safeguards problem over the one-pass plutonium recycle, MOX recycle, in that the fast reactors are fueled with about five tons the plutonium per gigawatt, taking the Superphenix as an example. Then you would need, oh, two or three times as much plutonium flowing through the fuel cycle as in the core of the reactor. So there will be a huge inventory of plutonium.

And I also think that even the R&D on this technology is a serious proliferation risk. If you would go to Oak Ridge, you could see a single hot cell where the Oak Ridge scientists demonstrated the advanced aqueous reprocessing technology from reprocessing spent fuel to production of 3 MOX pellets.

That facility, the staff that operates that facility and the materials that would flow through that facility are an ideal weapons program. So, when you hear discussions about proliferation-resistance of the fuel, you should not stop there. You should think about the spread of the technology, including the R&D technology, which I think represents a serious risk.

Now just one last comment. Earlier today, you heard a number of people talk about the rest of the world is going forward with reprocessing, regardless of what we do, and that is France and Japan and Russia and India, China. Also, the Netherlands reprocesses some in France. But you didn't hear them balance their presentation by telling you the following countries have abandoned the reprocessing: the United States, Germany, the Ukraine, the United Kingdom, Sweden, Spain, Belgium, Switzerland, Finland, Bulgaria, the Czech Republic, the Slovak Republic, Hungary, and Armenia. And the following have not yet reprocessed: South Korea, Canada, Taiwan, Brazil, South Africa, Mexico, Lithuania, Argentina, Slovenia, Romania, and Pakistan.

So I don't think it's a foregone conclusion that the rest of the world is going to head down a more costly once-through reprocessing track or develop and deploy large numbers of fast reactors.

Thank you.

CHAIR PETERSON: Thank you, Tom.

Our final speaker for this panel session is Dr. Geoff Rothwell, Geoff from Stanford University.

DR. ROTHWELL: Okay. So, to introduce myself, because according to this list, I represent Stanford University, and I don't think Stanford has designated me as a representative on this issue.

So, just to give you an idea of who I am, I grew up in Richland, Washington. So I can say that my father's aqueous reprocessing is PUREX. I was there. I put my hands in the glovebox.

Also, to give you a little bit of my background and biases, I have been working on Generation-4 since 2003. I've worked on GNETP. I'm working for DOE NA through Pacific Northwest National Laboratory in Richland, and now I am also a contractor with the University of Chicago-Argonne.

The statement that I've handed out -- and Matt is handing out my presentation and statement to the audience, I believe -- okay, this is from a chapter in a policy review being done at Johns Hopkins University. Several of the panel members are in this room right now.

The bottom line is that all alternative fuel cycles for the light water reactor used fuel and high-level waste required geologic sequestration. So I suggest the U.S. focus on finding a repository site and, when found, optimize reprocessing and recycling to best use that site with the budget constraints that we have.

The economics of MOX recycle, there are studies out there that show that these two, the once-through and MOX recycle alternatives are similar in terms of economics, and this is under two crucial assumptions.

First is that the cost of capital is not greater than 3 percent. That means that the U.S. Government is assumed to pay for everything. Okay? Assumed to accept all the risk. So we can come up with the economics to show that MOX is about the same cost as once-through if the government pays for everything and accepts all the risks.

You can show it as a fact, if you make the certain assumptions, that these alternatives are approximately the same, if the government pays for everything and you never place the MOX in the repository. Okay? With those two assumptions, you can get the economics to be approximately the same.

Now, on the economics of fast reactor recycle, this is a problem when there's too many unknown unknowns. Okay? We have some known unknowns and some unknown unknowns, and the problem with trying to get markets to work here, and we're going to be encountering this over and over again, and every time you try to get the commercial sector involved, is that markets do not do well with unknown unknowns. The financial markets are very risk-averse at this moment and should be risk-averse for the foreseeable future.

So it is the role of the government to reduce those, to identify unknowns so that they're then known unknowns and reduce the uncertainty associated with known unknowns. That is what the government should be doing.

At that point, once those uncertainties are resolved, then markets can step in and we can have, you know, a market in reprocessing, a market in repository, and so forth. But, until these unknowns are identified and quantified, so that a financial analyst can give a reasonable estimate of what the risk premiums are, what the costs of capital are, even though we've got plenty of commercial entities out there that are willing to step up and accept the government's money to start this program, Wall Street is not going along with it, as long as there's a lot of uncertainty. And there's a lot of uncertainty here, and it's up to the Commission to try to reduce that uncertainty, try to identify the risks, quantify those, and move on.

So what can we do right now? Well, this afternoon you could introduce, or somebody could introduce, legislation to strike certain parts of the Nuclear Waste Policy Act. Those parts that need to be struck this afternoon are in Section 148(d), Licensing Conditions. "Any license issued by the NRC for a monitored retrievable storage facility under this Section shall provide that, one, construction of a facility shall not begin until the NRC has issued a license for the construction of a repository under Section 115(d). Two, construction of such facility shall be prohibited during such a time as construction of the repository ceases." And, finally -- there's a lots of two's and three's and four's in there -- "Such facility at any one time may not exceed 15,000 metric tons of heavy metal."

Personally, I believe after growing up in Richland, I can live with this stuff, you know. This is not something that we have to bury immediately, we have to reprocess immediately. What we need immediately is to get the stuff off of some of the nuclear power plant sites, those sites that have been decommissioned or in the process of decommissioning, and we need to get that used fuel centralized.

Okay, what can be done soon? We should be optimizing -- this is what DOE Nuclear Energy can put money in, the government can put money in, the industry can put money in, to optimize the light water fuel cycle, to reduce used fuel.

We should reconsider the economics

of MOX reprocessing after we've started a MOX market in the United States. Right now, that's a subsidized market. If it remains subsidized, then we have to consider whether those subsidies are being spent in the right place. But, for right now, MOX is not commercial. We should see, after the completion of the Savannah River facility, we should see MOX in America, and at that point we can decide whether we want more MOX in America.

Lastly, we need to reduce uncertainties in the fast reactor recycle because that's basically, if everything was perfect and cheap, that's probably the way we would go. But it's not perfect, it's not cheap, and so we need to reduce these uncertainties, so we can evaluate that alternative more correctly.

So thank you very much for your attention, and I hope the audience got a hold of my statement. Thank you very much for your time.

CHAIR PETERSON: Thank you.

Now we do have time for questions, and I will go ahead and kick that process off.

I would first like to thank all of the panelists for presentations. They were very helpful. Combined with the presentations from the previous panel, it gives us a lot of information to work with.

I have three questions I would like to pose, and then I will turn things over to other Commissioners.

The first question is for Tom Cochran. Tom, in looking at the question of the economics of new nuclear plants, this really is an important issue because it does have to do with whether or not they can be competitive going forward as a source of energy.

So there's one thing you didn't mention in noting that the first plants that are going to be built are marginally economic in terms of the prices, which is a carbon tax or carbon cap-and-trade and its impact on relative competition. Of course, NRDC has a position on carbon cost.

Then the other part is associated with the fact that, in general, usually the first unit of a reactor type will be more expensive to build than the last. This has, for example, been clearly demonstrated with the experience in Korea, where the first units were about 30 to 40 percent more expensive than the subsequent units.

And in general, if we look at renewable energy, we tend to have policies that are willing to subsidize some of those first-of-a-kind costs in anticipation that that will bring forward the technologies that can subsequently be competitive without those initial subsidies. Of course, it is a small modular reactor; that happens a lot faster.

But could you comment on the consistency of position around subsidies for first-of-kind costs and then also on carbon cost?

DR. COCHRAN: Well, on the first-of-a-kind cost, we did that with nuclear. We subsidized the first generation of nuclear plants, and now we have a mature industry and competition, and they can stand on their own two feet. We don't have to continue ever after subsidizing mature energy technologies.

So I think there's a role for the federal government involvement upfront for new technologies, concepts such as a production tax credit to build an infrastructure to bring the first-of-a-kind costs down.

But, secondly, against my advice, the federal government chose in the 2005 Energy Act to subsidize first-movers. This was after one of the Commissioner's and his colleagues had recommended that perhaps we should subsidize a few first-movers to the tune of on the order of $200 million a plant to see if there's any real interest out there.

By the time Commissioner Domenici and his colleagues got through with that proposal, it was a billion dollars a plant subsidy, and that generated, you know, 20 proposals for new plants, some of which were built. But one of the underlying objectives, which was standardization of a couple of new designs, was not achieved by that proposal. Instead, we've got a whole slew of alternatives.

So I think we don't need to get into that business of subsidizing first-movers for small modular reactors. As others have observed, if it were clear that these small modular reactors were economic, they would be doing them today. If it were unclear, you wouldn't have all of these people sitting alongside me with their proposals for new reactors.

Let them put their own money up and take the risk and see if they've got a product that can compete. I think it's going to be a tough road because we have spent two decades building bigger and bigger reactors, trying to achieve economies of scale, and now the argument is that the manufacturing costs, savings, will offset those economies of scales and these things will be competitive.

I'm all for them using their money and Bill Gates' money to build these first-of-a-kind. Just stay away from the federal trough.

CHAIR PETERSON: Okay, now on the carbon issue?

DR. COCHRAN: Okay. I learned my economics, I'm not an economist, but I learned my economics two years at Resources for the Future.

We should pay the social cost of carbon. The most economical way to address the carbon issue is to regulate the emissions of carbon and let the market establish a price. And you either do that through the cap or through a tax. We were unsuccessful with the cap. But that's certainly the most economical way to regulate this pollutant. It is the way we regulate other pollutants.

The alternative of subsidizing your favorite technology is a very inefficient way to address the carbon problem.

CHAIR PETERSON: Okay. You didn't, of course, address the question about NRDC's position on subsidizing renewable energy sources.

DR. COCHRAN: I said I think there's an appropriate federal role for subsidies. It includes subsidizing new technologies that are attractive and are trying to enter the marketplace. At some point, there comes a time when the federal government should get out of the subsidy business.

Certainly we can debate whether that time has arrived for wind power and some other renewables. I don't think there's any debate, at least at NRDVC, that that time has long past for nuclear power, which has been in the market for 40-50 years.

CHAIR PETERSON: Okay. Now I would like to open the floor to the question of whether or not reactors are a mature technology and whether or not, in fact, there's the possibility that you can do things that are substantially different than as in the current fleet that would be beneficial, but as with other energy technologies, probably needs some federal help.

Chris?

MR. MOWRY: Well, first of all, just I think we all need to recognize that I believe wind power has been around several centuries, and it has evolved quite a bit. So I'm not sure where you draw the line in maturity of technologies, but I could certainly argue that wind certainly has had enough time to become mature.

But perhaps on a more serious note, a couple of things I would like to correct. First of all, from a B&W perspective, the purpose of developing SMR technology is not, repeat, is not to reduce the overnight capital cost in terms of dollars per kilowatt, because we do not believe that that is the impediment to faster, broader adoption of commercial nuclear power in the industry.

The impediments are cost and schedule certainty associated with megaprojects, No. 1, and, second, the absolute magnitude of the investment that is required to build a large power plant. The fact is that a large power plant, the capital cost of a large power plant exceeds the market capitalization of almost every utility in the United States. That is what we are trying to address.

We don't believe that the overnight capital cost of light water reactor technology is a problem because, when you're a utility, you don't really measure the economics of a project by purely overnight cost. You also factor in fuel costs. And for commercial light water reactors, fuel cost is approximately equivalent to 50-cent gas. So you are really looking at the total life cycle cost of a power plant.

And in that perspective, depending on who you talk to and under what conditions you're considering an investment, SMRs could be competitive with gas in the $5-to-$6 range. And certainly, if you apply some type of carbon tax, they are very competitive.

So I think you have to understand what the challenge is that the industry is facing today and why there are not more adopters of large reactors. We don't believe it has anything to do with the overnight capital cost, but it has to do with the structural challenges that a free-market economy has in financing megaprojects. So I think that that is one thing that has to be factored into the overall approach here.

DR. LORENZINI: Yes, I would echo those remarks and perhaps add a couple of other thoughts. I think it is hard to describe an industry as mature when the last plant that was built was ordered in 1973. There was something wrong, if that's considered a mature market, and no more plants have been ordered. So something needed to change.

Secondly, I think when you talk about subsidies, the threshold question should be: what's in the national interest? If it's in the national interest to pursue these technologies and help them get to the market, then that's something that ought to be considered in the area of subsidies. That, clearly, was the argument for wind. It was clearly the argument for renewables.

And if we are in a situation today where carbon is an issue, where there are only three sources of baseload electricity, and two of them are huge carbon producers, and nuclear is the one that isn't, then there ought to be a national interest in seeing what can be done to develop an industry that has been dead for 30 years. So I think that's the perspective that I would suggest we think about, when we think about subsidies.

The other thing, I would echo the notion that the issue here is the total capital cost of a new plant, but I would argue that for years the belief has been that you have to build big plants to be economic. I do think what we have done is we have shown that you can build small plants that are also competitive on a dollar-per-kilowatt basis. And that has changed the conversation.

And it's not just because you're looking at manufacturing. It is because of the simplicity of the designs. I mean you look at our design. There's no pumps, there's no pipes in the primary system. It's a very, very simple design.

So we save money by eliminating a

whole bunch of equipment that you don't have to buy. We call that the economies of small.

So I do think that there is now a new piece of information that we can achieve a price point that is competitive, in addition to putting a plant on the market that can avoid some of the large upfront investments. And if that's the case, and add to that the national interest in creating a U.S. manufacturing base that could be used for export, which small modular reactors can also do, they not only create an export market, they import jobs that are currently going overseas.

So I think there are a number of ways of looking at the small reactor market and viewing it as something that is in the national interest.

CHAIR PETERSON: John?

DR. PARMENTOLA: I think I agree with some of what has been said, but I think in the case of the concept that I described, there are significant research issues involved here. We don't have the knowledge completely to be able to do what I described.

And as such, my opinion, the federal government -- and I participated in federal government for many years -- its role is to either do what private industry can't do or won't do. One thing private industry doesn't do is high-risk research.

So, in my case, the reactor that I described, which is a small modular reactor, and I can make the arguments, the same arguments that have been made here about overnight costs and controlling schedule and using replacement parts manufacturing and supply chain management, Lean Six Sigma, and all those things that enable you to control and drive down cost.

There still is a set of research issues that are high-risk that need to be addressed. In my opinion, the federal government should intervene and try to address those issues in order to get to those five problems, national issues that I described.

CHAIR PETERSON: Okay. Let me follow up with one more question, and then I'll turn things over to the other Commissioners.

Chris Mowry mentioned some of the impediments to new reactor development construction, such as constraints on the supply chain and potential need for some federal support. There's also the question of licensing of new reactors. The next panel session actually is going to dig into that, and then we'll have NRC here as well.

But I have a question for NuScale and B&W because you are entering into this design certification process, which is, if you look at the FDA, they actually have a phased licensing process that allows you to address some really fundamental questions early on and provides off-ramps along the way.

And pre-certification review with

the NRC does some of that, but not really in a formal way. From your experience, would it be helpful if one could come up with a more systemic, phased process for licensing of new reactors?

MR. MOWRY: I think, from our perspective, it is actually yes and no. All right? And I think it depends on the technology and the program and the problems you're trying to solve.

I think that is where you see a bifurcation of the approach that is optimized, let's say, for near-term Generation-3 SMRs and Generation-4 SMRs. Generation-3 SMRs I would say, generally speaking, search to find a solution that fits within the current regulatory framework.

In that regard, technology changes that also require changes in regulation don't really fit within the goal of an SMR. Because the goal of a light water reactor SMR is really to provide a near-term deployment option.

I think, actually, this ties back into the subsidy question. You know, the utility industry has taken advantage of the recession to start retiring a lot of old coal units that do not have any environmental controls on them. That's because the requirements for electricity generation in the United States have actually gone down over the past couple of years.

By the end of the decade, that trend under almost all possible future scenarios is going to reverse, and as Dr. Lorenzini mentioned, you're going to need new baseload power generation. So utilities are going to be building baseload power plants. So it comes down to a question of timing, and we view a public/private partnership more as a matter of accelerating risk management than creating a vehicle to adopt a technology that is not viable on its own.

We believe, ultimately, this is

going to be viable. The question is, what role does the government have in adopting or creating technology options for the industry that are aligned with the climate change requirements?

CHAIR PETERSON: That makes sense. B&W would not be putting its own money into this technology if it didn't believe there was a commercially-viable product.

Paul, could you amplify?

DR. LORENZINI: Well, yes, I guess I would support the idea. If you look at where we are and you say, how far are we away from getting a certified design, it's probably five years from today.

Customers that would make decisions today don't want to make a decision if they're waiting five years to get any kind of certainty. Now there are interim points along the way in the process where you start getting certainty. So it's not as if you don't get some preliminary feedback.

But more feedback earlier, particularly on the key issues, would, I think, strengthen the process in terms of comfort with the technology, both for investors and for customers. Those are two critical issues for us.

CHAIR PETERSON: Very good. I think at this point I will turn things over.

Actually, I was making a list. So, Allison, you have a question, and then maybe Dick and then Susan. Okay, Allison?

MEMBER MacFARLANE: Okay. I have actually three quick questions.

The first is for Geoff. And seeing how we're talking about small modular reactors, I'm interested in your take on small modular reactors. I mean we haven't built small reactors; the whole global nuclear industry has not built small reactors. And I'm curious as to whether you think that they are economically-viable. We will start with that. And once you answer that, then I will go on to the next question.

DR. ROTHWELL: Submarine reactors are small modular reactors.

MEMBER MacFARLANE: Yes, but they didn't have to be economically-viable.

DR. ROTHWELL: Well --

MEMBER MacFARLANE: They didn't have to survive in a marketplace.

DR. ROTHWELL: Well, actually, I've just been hired by the University of Chicago and Argonne to look at this. So, you know, these are my impressions rather than immediate research.

That is, it depends on how many modules you can get on the site. If you are only talking about one or two modules, it is not that economic.

MEMBER MacFARLANE: So what is the size limit here in terms of megawatts-electric?

DR. ROTHWELL: It depends on what the balance of plant is, that part that you have to build --

MEMBER MacFARLANE: Yes.

DR. ROTHWELL: -- upfront, where you could add modules to it. So it is the cost breakdown between the balance of plant that has to be built --

MEMBER MacFARLANE: No matter what, right.

DR. ROTHWELL: -- whether you have one module or six modules and then the cost of the modules. The cost of the modules should follow this learning curve, but the balance of plant need not follow a 10 percent learning curve.

MEMBER MacFARLANE: Right.

DR. ROTHWELL: But I'm supposed to have my stuff done in a couple of months for Argonne.

MEMBER MacFARLANE: Okay. I would be interested in seeing it.

Okay, the next question. For all of you new reactor people, I am interested in that all these reactors are being put underground. So what are the issues there? What are the additional costs of putting them underground and what are the difficulties when problems come up with your reactor and dealing with those problems when it's underground?

I assume you are putting them underground for safety reasons, but tell me more about that.

DR. LORENZINI: Well, I will speak for our plant. It is not really underground. It is below grade. There's a distinction.

We build a building that goes down 75 feet, and there's a pool of water. The people that are on top are at grade level.

MEMBER MacFARLANE: Right.

DR. LORENZINI: So it's below grade. We do it because there is a security advantage to that, and we do it because we have seismic advantages to doing that.

MEMBER MacFARLANE: Yes.

DR. LORENZINI: We do it because,

by having the module immersed in a pool of water, we get safety advantages by doing that. And we really don't see huge issues. You dig a big hole in the ground for a conventional plant anyway. So digging a hole in the ground is not per se --

MEMBER MacFARLANE: No, no. Okay. Because there's a cost --

DR. LORENZINI: It's not that different. Yes. Yes, it's not that different in terms of cost.

In terms of our cost, you know, I will give a little commercial here. If you look at our plant, basically, onsite we have a civil construction job. I mean we build a basic concrete structure that is fundamentally full of water, and we bring the reactors in from the outside.

We've got a certification plan for a 500-megawatt plant. So we can take advantage of the point that Geoff made.

But if you're on the Island of

Saipan, for example, and you've got a 70-megawatt load, and you've got an $80-million-a-year fuel bill because all of your fuel comes from diesel, suddenly, the price point for a two-module plant starts looking pretty good, even though it's high -

MEMBER MacFARLANE: Yes.

DR. LORENZINI: -- sure, in the U.S. market.

So you have to look at this not only from the U.S. market standpoint, but from the global market standpoint --

MEMBER MacFARLANE: Right, right.

DR. LORENZINI: -- and that's a huge, huge market for us as well.

MEMBER MacFARLANE: Right. Okay.

And then the third, last question, is mostly for John, but maybe Tom wants to jump in, too.

That this kind of reactor, the gas-cooled fast reactor that you guys are proposing, I assume -- I think I know -- that one or two have been built in the past. I am wondering how successful it was and whether you think it's relevant at all to what you are proposing to do.

DR. PARMENTOLA: Those are both thermal reactors. One was Peachbottom, which was a small modular reactor. It was 50 megawatts. It had a high-duty cycle of reliability.

And then there was Fort St. Vrain, which was a large reactor. I believe it was like 350 megawatts.

MEMBER MacFARLANE: Yes, but have there been fast --

DR. PARMENTOLA: No.

MEMBER MacFARLANE: No?

DR. COCHRAN: GA proposed a gas-cooled fast reactor in competition with a liquid metal fast reactor and the molten salt reactor, and they lost out to the liquid metal. This was in the early seventies. They found some old designs, and they are coming back.

DR. PARMENTOLA: Yes, but, as I said, those are thermal reactors.

MEMBER MacFARLANE: Right.

DR. COCHRAN: Not the fast breeder, though. GA proposed, but did not build to the AC that they fund R&D to develop a gas-cooled fast breeder.

And you got funding for that, a small amount of funding on an annual basis from the Congress, but, ultimately, Milton Shaw went with the liquid metal fast reactor, and you were never funded to build the gas-cooled fast reactor.

CHAIR PETERSON: Okay. Dick?

MEMBER MESERVE: Yes, I would like to follow up a little bit on some of the licensing issues. I think this is most relevant to Mr. Mowry and Dr. Lorenzini because of the fact that you're nearer-term.

You are, obviously, are smaller and below ground. It changes the safety profile, security profile somewhat. I'm curious of the extent to which you are dependent on having some licensing issues resolved differently for your reactors than for conventional reactors in order to make this viable.

Arguably, I guess you might have an Emergency Planning Zone that will be smaller. If you have multiple modules, I presume you're looking for staffing limitations in control rooms that might not be allowed in a large reactor.

I am sort of curious about whether you have had enough engagement with the NRC to be able to assess the licensing issues that need to be resolved, and the extent to which they are showstoppers or at least critical impediments, if they don't get resolved the right way.

MR. MOWRY: I guess a couple of things. First of all, we have had significant interaction with the NRC and the staff, and actually, they have been quite open in engaging us with this conversation for the past two years. So I think we have a good feeling for the landscape in which we need to address these matters.

I would say that the answer depends on the application for the SMR. There was a previous set of comments around how many modules you were going to build. So, if you look at, let's say, the bookends for the application of SMRs, on one end you have single-unit sites or sites that are called nuclear greenfield.

And one good example for that would be the repowering of an old fossil site, where you may have a 150-megawatt coal plant that was built in 1950. You decide to retire it, but you have the existing transmission infrastructure, which, by the way, takes 10 years to site a new transmission line. You have a substation. You have water rights. But you don't have any existing nuclear infrastructure there.

The matters such as security requirements, an Emergency Planning Zone, we believe need to be addressed to improve the economics of the deployment of a reactor under those conditions because, otherwise, they do drive up the cost.

But at the other end of the spectrum, where you are talking about, let's say, building out additional units on an existing nuclear site, and there are lots of these sites around the country. For example, First Energy has sites where they -- well, actually, a lot of utilities have sites where they have only built a single unit where the site was originally designed for multiple units.

Siting SMRs in that type of environment really takes advantage of the existing infrastructure in terms of security, EPZ. In that type of scenario, you don't really need changes in these types of regulatory matters to make the SMR cost-competitive.

Even if you alternately build out, let's say in the case of B&W, you build eight of these things, you have an incremental 1,000 megawatts. But the point is that you build these one at a time, so you're not trying to finance $10 billion all at once. But at the end of the day, it's inside the fence, it's inside the existing EPZ zone.

And we would argue that in that type of deployment scenario we're really not looking for any substantive changes in the regulatory environment that we have today. The changes that we would look for are really there to improve the economics and deployment of nuclear power in places where it has not currently been used and in repowering scenarios and more initial applications, which we believe is important.

DR. LORENZINI: So we met with the NRC the first time in February of 2008. And at that time, we went through 255 sections of the Standard Review Plan, and we showed them that, with the exception of about 10 or 15, everything fit us. So we narrowed it down to those.

Those areas involve, No. 1, a control room where we have more than one reactor being operated out of the same control room. We don't see any showstoppers there. That's an issue that got first raised by the PBMR people. So the NRC conversations have been very helpful there.

The smaller EPZ, issues of security, and reducing security staff is, I think B&W says trading people for concrete. I think I kind of like that idea.

And also, we have issues about building an infrastructure and then adding new generation to that after you have existing generation operating. There are those kinds of questions, but we haven't had any sense that any of those issues are showstoppers or cause for great alarm. It's more a matter of, what do we have to do to go through this?

On the control room, for example, we intend to have a fully-operating simulator in place when we turn in our design certification application, just because we know that is such a critical issue.

CHAIR PETERSON: Susan Eisenhower?

MEMBER EISENHOWER: Yes. Again, thank you, all the panelists, for a very enlightening set of presentations. I think the small modular reactors are a very exciting development here in the nuclear field. So thank you for those presentations.

I did want to make -- I couldn't resist -- I want to make one observation, and then I have two questions. That is, simply, that speaking of mature industries, the coal industry is a mature industry, and it is going to have to be subsidized fairly well to get carbon capture and sequestration underway. I mean we're either serious about climate change or we're not.

By the way, I would like to say to that point, having visited our country's only full pilot project in this area at a coal facility in West Virginia, the parasitic load, electrical parasitic load, for capturing and sequestering carbon is so significant that maybe a small nuclear reactor might --

(Laughter.)

I'm serious about this. I think the problem in the energy field is there's so much siloing that nobody is really thinking about how one energy source might really lock in and help achieve another set of goals.

Now, having said that, one of the things that has not come up in any of these presentations is the question of -- this is my first question -- of U.S. global leadership and American competitiveness.

So could I ask people on the panel who would like to respond to this, what are you facing internationally around the development of small modular reactors? This, to me, would argue, of course, for the government taking an intense interest in the development of this. But maybe you could tell us a little bit more about what you're facing in the international arena.

DR. LORENZINI: I guess I would say it is not what we're facing; it's what the industry is facing because it's larger plants that are out there competing. But what they are facing is sovereign powers coming in and negotiating nuclear contracts and making it very difficult for American companies to compete. You've had Korea do that. You've had France do that.

And there is, I think, a need for the American Government to decide, is it in the national interest, to go back to my point earlier, to facilitate a global market? And one of the areas where I think that really is important is in the issue of manufacturing exports.

If we go to a country and we say we're going to build new scale plants and they tell us, "You can only build a new scale plant here if you do the manufacturing here," we aren't in a position to really argue with that. If the American Government believes there is an interest in having U.S. manufacturing jobs/export products, they ought to be there as a partner with us and say to these countries, "This is a good deal for you. We want to help make it happen, and in partnership with us, create American jobs." So I think that that's one of the areas where it would be really important.

MR. MOWRY: Yes, I guess I would like to add to that, just to put some historical context to this. Back in 1957, the Atomic Energy Commission partnered in a public/private partnership with Duquesne Light Company to build the first commercial nuclear power plant in this country at Shippingport. And that really launched this country's 50-

year leadership in the commercial nuclear power industry.

So that is a great example of a public/private partnership working and helping this country establish industrial leadership on a global basis. And what you see deployed around the world right now is really the outcome of America's leadership there.

And as Dr. Lorenzini mentioned, we have kind of lost that leadership on the large reactor side.

MEMBER EISENHOWER: Right.

MR. MOWRY: On the small reactor side, we have a unique opportunity right now in this country to maintain leadership in this emerging evolution in the light water reactor space. I would argue that there really are no global competitors today outside of the United States.

So it comes down to first in market, and the ability to deploy this internationally is also something that SMRs are uniquely capable of, because you can actually put an SMR reactor on a barge, on a ship, and send it overseas. So you can actually manufacture these things and send the critical high-technology component to wherever this thing is being installed.

Now that also speaks to security and non-proliferation. If you control that technology, you are really addressing this thing in a very practical manner.

But we are at a unique crossroad right now, and the question of how quickly this country develops the technology and makes it available on the international market is something that, ultimately, we believe is going to depend on the degree to which there is a public/private partnership that is in place.

And I can tell you, on the international side of things, if you look at, for example, the UAE, and a lot of other countries that are considering adopting nuclear technology, they have taken a country-of-origin approach. So a technology that is designed here and that is certified here through the NRC will likely be acceptable in new developing countries who are looking to deploy this technology.

So, really, the question is, who's going to get there first? Are we going to repeat what we were successful at 50 years ago or not?

MEMBER EISENHOWER: Right. Thank you very much for that.

I actually had a question for you, Tom, and you might, maybe two things here. First of all, on your U.S. Government, focus should be on, and you gave two points here. You did not have anything about research and development.

Now I know you don't like subsidies, but research and development is a slightly different thing. Would you say something about that?

And secondly, improving safeguards over nuclear fuel cycle activities, this is a very interesting and provocative statement. Would you give us some idea of what you think is inadequate at the moment? Thank you.

DR. COCHRAN: Thank you. Well, I did say there is a role for the federal government in support of the new reactor R&D, but I thought that role, I believe that role should be limited to educating new nuclear scientists, so they can do these designs and doing basic research, basic materials research, for example.

Now you mentioned the partnership with Duquesne. That was then. Now we have, I would characterize it as a mature industry. NuStart, I haven't done this calculation in several years, but when they were created, their combined assets were something like $200 or $300 billion, not counting Electricite de France or the French Government.

Their combined profits, or I

should say revenues, were in the neighborhood of $10 billion. They owned or operated 66 nuclear plants in the United States, almost roughly 60 percent of the fleet. You now have an industry that's perfectly capable of standing on its own feet. They don't need to come to the U.S. Government, for example, to get cost-sharing for licensing. The licensing will be a small part of their cost to develop the NuStart reactor. They simply don't need the federal money. They will be happy to take it, I'm sure, but they don't need it, and we shouldn't give it to them.

So that's my point. I'm all for them developing their reactor. I just think we don't need to engage there, and I think the Department of Energy's Nuclear Energy R&D Program, as it exists, is fine. I don't think we're going to get a lot from this Commission that will enhance what they are already doing in the way of reframing their program and focusing it on basic R&D.

Now on the safeguards issue, this really doesn't go to the issues in this particular panel, but it does go to the issues in the previous panel. The simple fact is that the existing international regime, safeguard regime, does not provide the fundamental safeguards requirement of timely detection of a diversion.

MEMBER EISENHOWER: Just a second. Just for clarity purposes, so when you say improving safeguards over the nuclear fuel cycle, you're talking about the international fuel cycle activities?

DR. COCHRAN: Exactly.

MEMBER EISENHOWER: Okay. All right. I thought you were talking about domestic fuel cycle activities.

DR. COCHRAN: My colleague, Christopher Payne, and I have a proposal for improving safeguards internationally, oversight internationally, beginning with uranium enrichment.

MEMBER EISENHOWER: Right.

DR. COCHRAN: It could be applicable to reprocessing other fuel cycle --

MEMBER EISENHOWER: Right. That's sort of a different subject. I thought, since you were talking about the U.S. Government focus should be on, and we were talking about domestic issues -- I don't mean to interrupt you, but I just think on this other point, John, did you --

DR. PARMENTOLA: Look, we invented nuclear reactors. I think we have reached a point where we need to reinvent nuclear reactors.

And what I described is not just a reactor. These gentlemen described a reactor. What I described was more than a nuclear reactor.

And if we are going to try to address the major issues facing nuclear energy, it has to be simultaneously addressing issues associated with what to do about the used nuclear fuel, the economics, the issue of increasing proliferation resistance, energy security, and a workforce.

I think that, based upon what I described as a fast reactor, it provides a unique opportunity for the United States to lead the rest of the world in a reactor that is more than a nuclear reactor. And I think it has the features of modularity, manufacturing.

And I'm not basing what I describe purely on guesswork. There is data to support what I claim. It is just that that data needs to be furthered and we need to be able to dig deeper into it, to make sure that the risks are reduced sufficiently, that we can move forward with the commercialization or at least the first-of-a-kind reactor of its type.

DR. COCHRAN: You should ask him whether he places a higher priority on that reactor or the government funding of the NGNP.

DR. PARMENTOLA: Okay, I'll answer

that question. Okay? I'll answer the question.

I didn't describe our overall strategy here. Okay? NGNP is a high-temperature gas reactor, but it's a thermal reactor. It has several very important features, in my view.

One is it is exceptionally safe. It's inherently safe.

Second, economically, it's more competitive than light water reactors because of its high efficiency. It is a much more highly efficient reactor than light water reactors.

Third, it has siting flexibility, all three of these.

Now that reactor can be built over the short-term to establish high-temperature gas reactor technology. EM-squared is the next major advancement over and above that, along a path toward establishing high-temperature gas reactors, not just for the

United States, but for the world.

CHAIR PETERSON: Very good. That is a logical explanation. Thank you.

I would like to turn next to questions from Commissioner Sharp.

MEMBER SHARP: Thank you very much.

I just wanted to double-check with, in particular, the two modular not high-temperature gas reactors on this question, in terms of what their requirements will be in terms of what happens to the used fuel for storage, for transportation, and for ultimate disposal. Is there anything qualitatively or significantly different that would affect how we judge those three systems that we would do for other fuel?

MR. MOWRY: From a B&W perspective, I think the answer is clearly at this point a no, and it's for a very simple reason. We are trying to design something that the utility industry, that the nuclear utility industry actually wants.

And if you look at the fact that we actually have a consortium that's actually putting their own money into helping further this thing, we need to really look to them to define their path forward in the used fuel, in the waste issues. So, at this point, they are not asking us to do anything substantially different.

Provide flexibility for future options? Absolutely. But to lead now would basically divert attention from the goal, which is to create a viable SMR that is deployable before the end of the decade. And if you do any of that stuff, you start monkeying around with new fuel designs, you're starting to push that deployment time from 2020 to 2030, and that is not what they are looking for.

So it gets back to a complementary approach that provides near-term benefits to the industry in the areas where they have pain today. And that's what a light water reactor-based solution can do, while at the same time supporting research to evolve promising technologies that have a longer gestation period.

So, for the part of the utility industry that is focused on near-term deployment requirements, the answer is clearly no, but I would have to defer the answer to some of the other gentlemen here who are looking to other designs with other goals.

MEMBER SHARP: No, but I assume your reactor, the EM-squared, is qualitatively different as a reactor. So I didn't know what does that do significantly in our thinking about waste storage, transportation, and disposal.

DR. PARMENTOLA: Well, I came here to talk about an advanced technology that could extract the energy out of what people normally consider to be waste. We don't consider it to be waste. We think it's a waste to think of it as waste. Okay?

(Laughter.)

MEMBER SHARP: I understand.

DR. PARMENTOLA: Simply put, right?

On the other hand, the NGNP can be demonstrated first-of-a-kind within the next 10 years as a modular reactor. Okay, it is not as small as these small modular reactors, but it is a modular reactor. It takes advantage of manufacturing and all those things as well.

In fact, we are partnered with Electric Boat that helps build the reactors in submarines to take advantage of all the modularity that they developed over the years to realize NGNP.

But in order to be able to move forward with EM-squared, there is risk that needs to be reduced --

MEMBER SHARP: Sure.

DR. PARMENTOLA: -- in order to be

able to capture the interest of others to see that, in fact, this technology can change the game in nuclear energy. We can change the way the world thinks about it.

MEMBER SHARP: I understand.

DR. PARMENTOLA: I use this analogy: if I lose my keys on the street, it seems that everybody always looks under the lamppost on a dark street, always under the lamppost. The answer lies someplace else, and this is the someplace else.

But you're driven by national policy issues to try and figure out how to address them.

MEMBER SHARP: Yes, I understand that, but what I'm trying to get at is the question that, if we say something about the character of current storage systems and their validity, or how long they might last, are we going to also need to be saying something about, but be sure to take this into account in order to allow for this?

When we talk about transportation safety and what is needed there, do we need to be saying anything that within the next 25 years you really need to be focused on some other kind of set of concerns when we talk about waste? You get what I'm saying?

That's all I'm asking, is trying to get a sense of how different the characterizations of what we might need are, not that we're going to settle these questions, but, hopefully, we will help others not to make the wrong set of choices along the path. That's all I'm trying to get at. Now maybe I'm not doing a very good job of even getting the point across here.

DR. COCHRAN: I just want to make a small intervention about what our priorities should be. There are other technologies that can use uranium more efficiently. For example, a uranium enrichment plant, we can run them at extremely low tails assay uneconomically and extract more energy per pound of uranium you mined. It makes no economic sense to do that today.

We could operate uranium mines and take out every uneconomically trace mineral in order to use the ore more efficiently. We don't do it because it's uneconomic. You take out the trace materials that are economical to take out and that have a market value.

So the issue with this reactor is really not the efficient use of the resource. It's whether it's going to be economical. My bet is, if he's got a fast reactor and he's using sodium, forget it. We've been there. We did that. They are not very attractive, at least when you look at the history of the program.

MEMBER SHARP: Well, I understand. We're probably not going to select reactor technology here. At least I'm sure you sure don't want me doing it.

Can I ask one more question, though, of Tom Cochran?

Among the things that you suggested we ought to focus on is getting the repository system back on track, and I wondered if you have any practical advice for us.

DR. COCHRAN: My advice that I gave the last time that I testified to the full Commission was understand the history well of the program that we are cancelling and understand the foreign programs, particularly the Swedish and I guess the Finns, and go from there.

There are lots of things that were done wrong, some involving you, some involving others on this panel.

(Laughter.)

MEMBER SHARP: I will confess. I will confess and try to repent.

(Laughter.)

But let me suggest to you that one of the practical difficulties we have on so many of these things is we always know what we don't like because it's what we have experienced and known. So there's always something over here.

And my impression is rarely do we on institutional issues give significant thought to what is the design of the new institutional issues. It's almost always driven by, I might say, all kinds of people in academia and industry, and everywhere else, who say, "Boy, we've been through this and we know don't do that." But oftentimes, what was done is actually related to inherent technical and social and political things that are going to repeat themselves; I don't care what you think the history has been.

DR. COCHRAN: I'll tell you one thing you should absolutely not do. You have a Nuclear Waste Trust Fund. You should, whatever you do, make sure that that Trust Fund is only used for the repository development.

The game plan of some people is to

take the institution responsible for developing the repository out of the government, set up a non-government institution or a quasi-government institution, and give it authority over not only the repository, but all the back-end of the fuel cycle.

So now the institution is responsible for, if it wants, reprocessing, transportation, whatever. And then you give it this huge pile of money. That's the only way some industry people see as the option for funding technologies that are not cost-effective.

So, if you want to build a $25 billion recycle facility, then move the program out of the government, take over the Waste Fund, and stack the Committee or stack the new Board of Directors so that they will fund your new $25 billion program.

So, to me, that is the biggest risk I see in the Blue Ribbon Commission, is that it will make a mistake and allow the Congress to do that.

MEMBER SHARP: Well, my only challenge to that, Tom, I think was raised the last period on the other Subcommittee, is this takes serious thinking through of what are the functions you want to be performed, what is the financing, what is the oversight. And the governance issues are central in anything like this.

And just this notion that we will create a new Federal Reserve which will somehow magically always make the right decisions, I don't buy, anymore than I buy the fact that we have done a good job of how we have managed it all the way through before.

CHAIR PETERSON: Okay. I'm going to note that, while we are running into the lunch hour, we did have a late start. So we are going to take just a few more minutes, and we are going to cut them out of everybody's lunch. But I know that people want to still have time.

So I will ask Al for a quick question, and then I will have one final question, and then we will wrap things up. Okay?

MEMBER CARNESALE: Thank you.

Two parts. The first is, as I hear the discussion, the argument with Tom as to whether the industry is mature or not is that others use words like revive, resuscitate, and dead, literally.

(Laughter.)

Literally. No, I mean this seriously.

So my question that arises from that, is it that you believe, independent of the waste question, which is a big part of the problem we have, but not the sole problem, especially of this Subcommittee, that nuclear power, as we know it, large-scale LWRs, do you believe that it is dead or close to dead? I am not talking about the operating plants. I am talking about new plants in the United States.

Or do you think, just as you were talking about, I've got a better idea?

DR. LORENZINI: If you are asking me that question, I used the word dead. If you go back to 1985 and you look at the infrastructure N-stamp suppliers, and you compare it to 2005, when the Energy Policy Act was passed, they all went away. If you look at where the forgings were being done, they were being done in Japan because the U.S. operations went away.

So saying that something is dead in the sense of having an industry infrastructure that exists, that you can go out and build a plant, that you've got qualified suppliers, you've got qualified vendors, the industry is there, you just build another plant, that went away. So it has to be reformed.

When we go to customers, you know,

it's going to be the first plant. Who's going to pay the extra cost associated with being the first plant up? We're talking about a government program to provide subsidies on the cost of the nth plant. Like, I mean, wind is out there, and they're getting subsidies on their operating windmills for years. We aren't asking for that. It is just get a first plant up and running and overcome some of those first costs associated with doing that.

MEMBER CARNESALE: And it could be sort of a traditional LWR gigawatt --

DR. LORENZINI: Well, I don't see us as traditional. I think we bring something different to the market.

MEMBER CARNESALE: No, no, I know. No, I'm trying to --

DR. LORENZINI: So I'm looking at it from when I talk about ourselves.

MEMBER CARNESALE: My question, you understand I'm not trying to be cute.

DR. LORENZINI: No, no.

MEMBER CARNESALE: I'm trying to figure out, is this something, looking at these alternative designs, is this something that you see as essential or something that you see as attractive?

DR. LORENZINI: That's a different question.

MEMBER CARNESALE: Those are not identical.

DR. LORENZINI: That's a different --

MEMBER CARNESALE: Oh, no, that's what I said. Do you think it's essential or do you believe it's otherwise? Now maybe you don't like the question.

DR. LORENZINI: Well, no, I love the question.

(Laughter.)

I would say that's a different issue of whether the industry is dead, is whether or not --

MEMBER CARNESALE: Well, the industry is dead because there hasn't been an order.

DR. LORENZINI: Yes.

MEMBER CARNESALE: I want us to keep an infrastructure --

DR. LORENZINI: I would go back to my earlier comment and say, if you're looking at carbon and you're looking for baseload generation, the only non-carbon source of baseload generation that's significant and readily available is nuclear. And if there's a barrier to nuclear because of the high financing, there's an option out there that says you can introduce nuclear plants into the marketplace and you don't have to face that high financial barrier; plus, you can reach markets that aren't being reached right now, yes, I would say it's essential.

MR. MOWRY: Yes, and I would like to reinforce that comment. I mean, if you look at the parts of the industry that are considering building new large gigawatt class reactors, they are really only the very largest institutions we have out there and, frankly, institutions that already have nuclear power plants.

If nuclear power is going to be part of a portfolio of solutions that addresses the climate challenge, you have to broaden the base of industry that nuclear power can access. So I don't think it's the right way to look at it as one or the other.

There's always going to be applications for large reactors. The large utilities will be able to, one way or another, afford large reactors. But you're talking about the smaller guys. How do you get a nuclear reactor into a utility that's only got a couple of thousand megawatts of generation? They will never be able to afford a big reactor.

And if you look at the number of high-carbon-emitting power generation sources that need to be replaced over any reasonable amount of time to address climate issues and energy security issues, you need to find a way to be able to deploy nuclear power into those areas as well.

So I think that it is a complementary approach rather than one or the other.

MEMBER CARNESALE: Thanks.

DR. PARMENTOLA: I would say essential, and in the case of a high-temperature gas reactor, there's a whole new set of customers for the energy output from that reactor. Because it's a high-temperature gas reactor, it can be used in process heat application.

And industry, the chemical industry, the refining industry uses process heat, but they basically generate it through gas. And then the question becomes, well, do you want to deal with the price fluctuations of gas and do you also want to deal with the

CO2 emissions from gas? Where you can get away with it with a high-temperature gas reactor, but it provides a new customer base.

What's more, EM-squared needs light water reactors because they produce the fuel that we use. So we are complementary to them in that sense. Okay?

DR. COCHRAN: I was just going to say in some areas of the country, particularly the Southeast, I think you will see a few new nuclear plants justified on the basis of other than their low cost. But, even there, they are dependent either on federal subsidies or getting the costs in the right base before they start producing electricity, which is reasonable from some perspective. It has some advantages to the customer. It has some disadvantages as well.

But I would also point out in terms of whether industry is alive or dead, it is now a global industry, and you are building 40-50 plants around the world. So industry is alive. It's just less in the United States, other than what's left of Westinghouse and General Electric, who have partnered with the Japanese.

MEMBER CARNESALE: Thank you.

The other thing I wanted, if I could, was just I was following up on Allison's question before about, how come the French and the British and the Japanese, we don't hear more about them with modular reactors, since they've had a lively industry for the last 20? They have had orders.

CHAIR PETERSON: Al, can I rephrase that question? Because that is actually exactly what I was going to ask.

MEMBER CARNESALE: As long as it is the same question.

(Laughter.)

CHAIR PETERSON: Yes, I promise that it is.

DR. PARMENTOLA: The Koreans have a program in small modular light water reactors.

CHAIR PETERSON: Yes, as do the Japanese.

One way of looking at that, there's another dimension to that, which is that a part of what enables the new small modular light water reactors is the use of passive safety systems because that eliminates the need for a lot of redundant, extra equipment that would be prohibitively expensive if you were to try to, I think, bring down to this scale multiple redundant safety trains.

And to amplify on that question, in the United States the regulatory system developed code scale inapplicability on certainty analysis methodology, very novel approach to integral-effects testing, facilities built at Oregon State University, and now B&W is moving forward to build these same types of experimental facilities.

So I guess I would ask, is there

any other regulatory authority in the world that could actually for the first time license these types of reactors, given that it's really U.S. NRC that has developed the capacity to do that?

DR. LORENZINI: I guess our view is that there are others that could because there are others that license light water reactors, and we don't believe there's anything strange about licensing our plant as compared with other light water reactors. The issue for us is, is that where we want to invest our resources?

And to go to the point that I think Chris made earlier, as we look at the global market, other countries want a technology that has been deployed in the host country first. And if we go to them and we say, "Buy our plant, but we've never built one in the United States," they don't want to be the world's guinea pig.

So they like the idea that we have

developed our plant in our host country and we are deploying it there. Once we do that, I think that there is a huge, huge global market.

On the issue of the global market, the other thing I would say is, if we went back to five or six years ago, there was like 90-some small reactor designs out there. There's small reactor designs, water, non-water, all kinds of small reactor designs.

The world of small reactor designs was focused on small grids, developing countries, remote locations. And what has changed in the last two years is the realization that there's a price point that the small reactors can reach that makes them competitive on a dollar-per-kilowatt basis with bigger plants, and there are ways to deploy them so that they can meet the needs of larger utilities as well. That is what has changed the conversation in the last two years.

CHAIR PETERSON: Okay, and I will have to apologize to Al because I may have taken your question a little bit astray, actually.

But, Chris, do you have, also --

MR. MOWRY: Well, yes, I just wanted to echo that. I think the key point here is that we see signs on a global basis that the world is taking a stronger look at SMRs.

This gets back to the commentary we had earlier, that there's a window here of leadership, and somebody is going to emerge as the leader in this industry, but it will happen. So, in terms of the waste issue, of course, that implies, again, that light water reactor-based fuel and used fuel will be around for a long, long time, irrespective of how quickly we can develop fourth-generation technologies.

So, whatever solution we come up with, both in terms of the domestic solution and to the degree that we care about non-proliferation security, it needs to take all of this into account.

So whose reactor is going to be built in Jordan? Is it going to be our reactor? Is it going to be the French reactor? The Korean reactor?

When they build an SMR there, whose technology is it going to be? Who is going to control that technology? Are we going to have an opportunity to have a hand on the wheel, or are we going to cede that control to some other entity? That's a very important question here that's wrapped up, I believe, in everything all of you are considering.

CHAIR PETERSON: And just to finish up on that question, the export issues, I'm sure that Jack Fuller would also be able to say a few words about whether there is a level playing field for the U.S. in the export market relative to other countries. I do think that is an important issue. So, at least just to get it into the record, maybe if we could get that covered quickly, and then we will break for lunch.

MR. MOWRY: Just the one data point I would have is that we expect over the next 20 years that 90 percent-plus of net new baseload generation will be outside of North America. So, if we want to have a vibrant industry and an economy that is built off of exports as well as things we do internally, we have got to be able to focus on that market.

CHAIR PETERSON: Geoff?

DR. ROTHWELL: This gets back to what you were saying about France. And here we are in a country where we rely on the markets. The French, as far as I can tell, that isn't really a part of their raison d'etre.

(Laughter.)

They have got a completely integrated industry, and we are competing with those completely integrated industries. The Russians have a completely integrated industry. They have no clue what their costs are. It's whatever they can get in the marketplace. Okay?

The Canadians have had an integrated industry. The British have had an integrated industry. We have not.

So, when we are talking about subsidies, there are so many ways you can subsidize an integrated industry that you don't even see because the cost of capital is integrated into that industry.

So we are competing with some very powerful players out there. And if we want to be in that competition, we have to sort of get together.

CHAIR PETERSON: Thank you. I think that that is a great way to end up this second panel session.

I apologize to everybody that we have been running a little bit late. But we want to make sure that we have sufficient time, also, to cover the afternoon topic.

So I would like to thank our panelists for this session, and then to note that we will reconvene at 1:30, the normal time.

I apologize that we are compressing the lunch period for everybody, but it is best that we provide enough time to make sure that we cover all of the issues that we want to here.

So we will reconvene at 1:30.

(Whereupon, the above-entitled matter went off the record at 12:47 p.m. and resumed at 1:30 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:30 p.m.

MR. FRAZIER: Senator Domenici?

CHAIR DOMENICI: We have Panel No. 3 now, and we're going to proceed.

Our third and last panel for today is entitled "Enabling and Incentivizing Commercial First-Movers". For this panel, the Commission asked the panelists to consider the following questions:

One, "What federal actions, and those are considered to be tax incentives, regulations, et cetera, that could address first-mover barriers and facilitate the development and commercial deployment of new commercially-competitive nuclear energy technology options?"

And two, "Are there ways to rethink price signals for nuclear generation and/or waste that could make nuclear power more competitive to build?

So, as the previous two panels,

speakers are reminded that they are to keep their presentations to 10 minutes or less, and that the remainder of the time we have will be spent on questions, like we did this morning. And hopefully, they will be as provocative and beneficial as they were.

Let me introduce our first panelist, Ms. Rebecca Smith-Kevern, Director of DOE's Light Water Technology Program.

Our second panelist will be -- well, let's take the first one and proceed. Go ahead and start, ma'am.

MS. SMITH-KEVERN: Thank you, Senator.

I am here to talk today about the specific incentives of the Nuclear Power 2010 Program and the Energy Policy Act of 2005 incentives for nuclear power.

The reason why the government is involved with nuclear power is that it is a matter of public policy. It supports the Administration's climate change and energy security goals.

The 104 operating nuclear plants provide clean, reliable baseload power. They are generating about 20 percent of our electricity mix today and providing about 70 percent of the emission-free electricity generated in this country.

On an annual basis, that avoids about 700 million metric tons of carbon dioxide. It also helps to reduce the overall emissions of nitrogen and sulfur.

To keep this fraction of nuclear power is not going to be easy, as electricity demand is projected to increase by 28 percent by the year 2035. As electricity demand increases, so will the annual emissions of carbon dioxide. Keeping the 104 plants running as long as safely possible at a high efficiency and as high an output as possible, as well as building new nuclear power plants, is needed.

So, if we have this case for

nuclear, why is the industry hesitating? I think you can see from this graph that is a matter of economics. Even one nuclear unit represents a significant fraction of the market capitalization of even the largest electric utilities. As you can see, the cost of one unit exceeds the market capitalization of some of the current active players, such as Constellation and SCANA.

Other reasons for the electric utilities' hesitation are the uncertainties inherent in the process. These uncertainties are interrelated, but the first is the regulatory uncertainties.

Power companies lack the confidence that the new, untested, one-step regulatory process, which I'm going to talk about on the next slide, is going to work as predicted.

Second is the technical uncertainty. They are considering new types of designs that have not yet been built anywhere in the world, and the concern is that the first-of-a-kind engineering will take longer and cost more, which leads to the financial uncertainty.

Part 52 is the new licensing process that the Nuclear Regulatory Commission developed and rolled out in 1989. As opposed to the old process under which the current 104 plants were licensed, that old process was a two-step process, and that involved a construction permit that the utilities got. Then, they began to build their plants. And once the plants were completed, they went back to the Nuclear Regulatory Commission for an operating license.

This meant that they had outlaid their capital before they had a guarantee that they were going to be able to operate and realize a return on that investment.

So the Nuclear Regulatory Commission revamped its regulations and established a one-step, combined construction and operating license, which is intended to complete the licensing requirements prior to the beginning of construction.

The other important difference in Part 52 is that it was envisioned as a modular process. The Nuclear Regulatory Commission allows for the certification of a reactor design. The reactor vendors can develop and get a design certified that is irrespective of a utility that wants to build it or a site upon which they intend to build. So the idea was that these designs would be available and ready to go off the shelf.

They also established in Part 52 the early site permit process. In this process, a utility could bank a site for up to 20 years, and in doing so, they would address the site safety, environmental impacts, and emergency planning aspects, and they could do so, if they so chose, generically by using a plant parameter envelope which would bound the conditions for many types of plants that they might want to build there.

The most important thing is that issues resolved in design certification and ESP processes were not reconsidered in the COL process.

That leads --

CHAIR DOMENICI: Would you state that again, please?

MS. SMITH-KEVERN: Certainly. Issues that were resolved in the design certification rulemaking and in the early site permit process are not to be reconsidered during the construction and operating license phase.

This leads to the programs that the government developed to address the uncertainties that I mentioned. Nuclear Power 2010, which has two major pieces, the early site permit project and the new plant licensing demonstration project, addressed regulatory and technical uncertainties. The Energy Policy Act of 2005 contained three important incentives for nuclear: loan guarantees, standby support, and production tax credit. And these were designed to address financial uncertainties during different phases of a nuclear project.

Nuclear Power 2010 was initiated in February of 2002, and it is an important context to recall that, back then, no electric utility in the United States would talk publicly about considering a nuclear project.

Nuclear Power 2010 was based on the near-term deployment road map, which talked about things that the government could do to incentivize nuclear power. Specifically, it talked about a government/industry cooperative effort which would be 50/50 cost share. These projects were competitively-awarded and they encouraged the development of consortia of electric utilities, which turned out to be important in encouraging standardization.

These projects were also utility-driven, in that the utilities proposed the technologies that they were interested in investigating and not the government.

The primary purpose of the Nuclear Power 2010 Program was to reduce the cost of the first plants so that we could get to the next plants.

Getting into more detail about the scope of the Nuclear Power 2010 Program, the first part of the early site permit project was the exploration of sites for new nuclear plants. We did several scoping studies that looked at sites around the country that might be suitable for nuclear plants.

Then we got into specifics of demonstrating the early site permit with three projects, one at Exelon's Clinton Plant, one at Entergy's Grand Gulf, and for Dominion's North Anna Station.

The two combined construction and operating license projects were part of the new plant licensing demonstration project, and they developed reference applications for the ESBWR through the Dominion utility and for the AP1000 through the NuStart Consortium.

The new plant licensing demonstration project also developed new light water reactor designs. We cost-shared the design certification for the Economic Simplified Boiling Water Reactor, the ESBWR, developed by General Electric, Hitachi, and the AP1000, which is under development by Westinghouse.

In addition to the design certification, we are also cost-sharing first-of-a-kind engineering, which is the engineering required to actually build a plant.

Therefore, we are achieving our goals of paving the way for industry decisions to build new advanced light water reactors by reducing the technical and regulatory uncertainties.

I take it I need to move along.

You can see the early site permits. I think it is most important to mention here that 17 companies have submitted applications for 26 new reactors, and that there are five designs currently being certified.

Very quickly, to the Energy Policy Act of 2005, there were three incentives: the loan guarantees, which support nuclear projects during the planning phase; standby support delay risk insurance, which supports projects during construction, and production tax credits that support nuclear projects during operation.

I think most importantly, the loan guarantees reduce the overall project cost by reducing the cost of borrowing. The current authority for Nuclear Power 2010 is $18.5 billion, and we have made a request for an additional $36 billion, to bring the total up to $54.5 billion for advanced reactor projects. There was also $2 billion in authority for fuel cycle.

Moving towards construction, we have orders for long-lead equipment. There have been engineering procurement and construction contracts signed. And I think most importantly, site preparation work has begun at the Vogtle plant, the Summer plant, Calvert Cliffs, and the South Texas projects. In addition, the Tennessee Valley Authority has resumed construction at Watts Bar Unit 2.

And, in sum, nuclear power is a key element of U.S. energy strategy. Despite the fact that we have removed substantial barriers, decisions to move forward still reside with each individual utility and its unique set of decision criteria.

CHAIR DOMENICI: Thank you very much.

We will proceed with the next witness, Mr. Mike -- are you going to help me with your name? Cazaubon?

MR. CAZAUBON: Cazaubon, yes.

Thank you, Senator.

CHAIR DOMENICI: Cazaubon. And he's the Manager for NuStart Energy.

MR. CAZAUBON: Thank you.

CHAIR DOMENICI: Please proceed.

MR. CAZAUBON: I am with Excelon Generation and am serving as Project Manager for NuStart.

First, who and what is NuStart? And with all due respect to Tom Cochran at NRDC, I would like to point out that NuStart is a special purpose entity. It does not own any assets. It is not building any plants. It has a very limited shelf life. It is only going to be around until about the middle of 2012. And having just gone through the budget process for 2011, I can guarantee you that we have to fight for every dollar from the members we can possibly get.

So, that said, I would like to say that NuStart Energy does have 10 member-owners. They are listed on the slide here.

I won't repeat them.

And the NuStart Consortium is comprised of NuStart Energy Development, LLC, the special entity, plus Westinghouse and GE Hitachi Nuclear.

Just a little more background about NuStart. It was formed in April of 2004. Its vision is to make nuclear energy part of the country's future energy solutions. Our mission at NuStart is to demonstrate that a combined construction and operating license can be successfully and economically achieved using the NRC's Part 52 process.

We are also charged with assisting in design finalization of the Westinghouse AP1000 and GE Hitachi ESBWR advanced passive light water technologies.

And from our perspective, we really try to emphasize standardization, safety, and good operability. So the vendors are doing the bulk of the heavy lifting, but we go in and help out where we can with practical suggestions from our operating experience.

So we definitely believe in a win/win solution through our teamwork approach to things, both with the vendors and with our partners at DOE and among the 10 member-owners of NuStart. I think that has been important in having a unified purpose and allowing us to move forward effectively over the past several years.

We were selected by the DOE for a cooperative award under the NP2010 program in 2005. And the work that we did at NuStart helped to support submittal of 18 COL applications for new projects, and that was from 9 of the 10 NuStart members.

As Rebecca mentioned, the COL at Southern Vogtle is one of the lead projects. It is the lead U.S. AP1000 project, with an anticipated COL issuance date of 2011, late 2011, if the reviews go as well as we hope.

I think most everyone has thought

about these before, but these are the challenges or at least a partial list of the challenges utilities face as a nuclear first-mover.

Surprise, we're a very risk-averse group. I have worked in other industries, and it was interesting how risk-averse utilities can be. It comes from the nature of being the rate-base history for a lot of us. Those of us who moved into the competitive marketplace have to retool our thinking a little bit more to try to be a little more nimble in that regard.

There are a lot of policies, uncertainties on carbon, renewables, tax credits, et cetera. It all affects the kind of economic considerations that we make. The regulatory uncertainties, licensing, legal challenges, cost recovery, are also a primary concern.

We have talked a little bit about technology. The construction cost, also, as previous speakers have mentioned, the absolute size and the uncertainty of the investment give a great deal of pause to potential first-movers.

And I have talked about competitive markets a little bit. If you overlay on top of everything else the uncertainty and alternate forms of energy pricing and how much demand there is in the macro-economic environment, it adds another layer of uncertainty that we have to deal with. Of course, there is the spent fuel management and fuel cycle considerations that we have to deal with as well.

NuStart tends to focus on two broad areas, the regulatory uncertainties and the technology uncertainties. That is where we have been putting our effort for the past several years.

As Rebecca mentioned, the DOE is administering the NP2010 program, designed to reduce the uncertainty in our decisionmaking processes within the utilities, which we are greatly appreciative of. It is 50/50 cost-share, but it has actually stimulated a lot more investment from utilities than 50/50, and I will talk about that more in a second. Fiscal year 2010 is our final year of funding under NP2010.

Okay. So NP2010 and NuStart, this is an example of what the federal support can do. In our estimation, because of NP2010, it really spurred the industry to move, and moved us at least two years ahead of where we would have been if NP2010 hadn't been put into effect.

So it has also provided us a vehicle to group and pool our interest and our expertise, and it reduced the ante or the cost of each person or each utility coming in. So it was an important way to convince senior management, who are very frugal with our dollar, to say, okay, put a few million dollars into NuStart; let's see what we can do together to move the ball forward.

So NuStart became a vehicle for licensing and the design standardization. The intent was to reduce both the industry cost, but, also, the NRC cost. We have tried to approach a one-issue, one-review, one-position philosophy on everything we did.

So standardization can reduce cost in the regulatory arena. It can reduce in design. It can reduce in construction, manufacturing. It is just the right thing to do.

So, instead of individual projects like we have had in the history of the industry in the past, we wanted to standardize as much as we possibly can.

NuStart has also served as a model for the design review, a standard review that other technologies have adopted at the encouragement of the NRC.

And as Rebecca mentioned, the Energy Policy Act of 2005 was an important inventive for the industry. And NuStart's preparation for NP2010 helped us be prepared to take advantage of applications for loan guarantees, production tax credits, and the regulatory risk protection afforded by the Act.

So, in summary, uncertainty and risk, you have to reduce that for the first-movers to act. In regulated markets such as what Southern has down at the Vogtle project, they have some ability to mitigate that risk because of their ratepayer base. But those of us in competitive markets have to look to reduce the other risk as much as we possibly can.

The industry partnerships I think have been crucial in achieving the effective and efficient deployment at least of the preparations for the next wave of new reactors.

The coordinated effort with government has helped to accelerate that. So it is has been a selective acceleration by at least two years in what could have been otherwise.

And as you know, the regulatory process is a big, big concern to the first-movers. So a demonstrating of Part 52 success is vital to reducing that risk.

But, ultimately, the investments will have to pass economic muster. So we reduce the risk where we can, but it still has to make sense for the for-profit utilities.

Thank you.

CHAIR DOMENICI: Thank you very much.

Our next panelist is Dr. John Kelly, who heads up the American Nuclear Society. They have a Special Committee on Small Modular Reactors, and he heads that up.

Dr. Kelly?

DR. KELLY: Yes, thank you, Senator.

Today I am speaking on behalf of

the American Nuclear Society's Special Committee on Generic Licensing Issues for SMRs. I'm co-chairing that Special Committee, and we started our work in January of this year. And I'm giving a report on where we are at with this effort.

I think we have heard earlier today about the potential benefits of SMRs, changing not only social paradigms, but also energy supply paradigms, with job creation, a basis for export of reactors, supports national security and energy security, and has climate change benefits.

And certainly the ANS President Tom Sanders has been a very vocal advocate of SMRs. So it was under his initiative that this Committee was formed.

Now the dialog with the regulator, the NRC, has been ongoing for the last 10 years with a number of the designers, project developers, et cetera, on a licensing approach for SMRs. And then, about a year ago, here in

Washington, the NRC had a workshop where they brought together all interested parties to start the dialog on getting serious about addressing the regulatory issues.

And what they encouraged was that the industry get together and come with a common consensus approach at least on the generic issues, so that these could be dealt with once and have applicability to all the vendors.

So, after that workshop, President Tom Sanders called myself and some others to form this Committee. What we strived to have was cross-cutting participation from ANS members with every SMR perspective. This meant government, regulators, industry, academia, National Labs, et cetera. So it is really a broad-based Committee of ANS members. And we wanted to be collaborative with other efforts, such as those going with NEI, IEA, EPRI, and the DOE program.

So there's about two dozen issues

that have been identified as generic or technology-neutral issues. I am not going to read through all of these.

But, basically, the game plan for the Committee was to write White Papers that address what the issues were associated with each of these issues and then propose solutions of how they could be addressed in the regulatory process.

So it was very issue-focused. We are technology-neutral. So we kept an open mind about all technologies, gas, water, liquid metal.

And we basically took that list of two dozen issues and put those into three subgroups, one on licensing framework, one on licensing application, which really has to do with the content of a license application, and then the licensing associated with the design and manufacturing of an SMR.

There is tremendous interest from the ANS community in this activity. We have nearly 3 dozen companies, organizations, that have participated in this effort, really representing a very broad cross-section of the nuclear science and engineering community.

Now we just concluded an interim report. It is in final editing right now. And, Dr. Peterson, I will provide that to you and the Committee as soon as that gets through the editor. But that is the stage that it is right now.

Of those 24 issues, we addressed eight of them in the spring timeframe. We are now planning to address an additional six, but that will probably be done late in the year. So it is not clear that the timing will be consistent with the timing of this Committee, but we'll see.

So they are listed here in terms of the issues that we addressed. Then I am going to talk a little bit about these in a little bit more detail in just a couple of slides here. Okay.

So conclusion from the papers that we developed is that the current regulatory system is geared toward large light water reactors. This, in itself, isn't a bad thing, but it does introduce the need that for SMRs there's probably a number of the regulations that would have to be, exemptions would have to be sought by an applicant.

And in our view, this was not a desirable long-term solution. So, for first-movers, you know, having a license application that seeks exemptions is probably workable, but it is probably not a long-term solution where we are talking about potentially thousands of small modular reactors, that we need a longer-term solution.

The Committee is recommending that it be a risk-informed, technology-neutral approach. There was some effort in this a few years ago by the NRC to develop such a framework. So we see that as a mechanism for a long-term solution.

Now, to enable this, it is going to require some changes to the regulatory framework. This can be done either through rulemaking by the NRC or through legislative changes. And in our White Paper we at least begin to indicate how that may come to be, and we are not pre-judging how it could be done. I think the NRC does have some flexibility within the current Atomic Energy Act. So we are at this point making suggestions on how best to proceed.

Now, in general, the issues fall into three broad categories. The first is the financial issues. The issue here is principally, with the small electrical output, the revenue base for a plant is smaller, and so, therefore, certain costs, certain fixed costs associated with the regulatory process can become a significant fraction of the revenue. So this is a particular issue in terms of the economics of the SMRs.

Two things that we have written

papers on. One was the Price-Anderson, where this is basically the insurance for catastrophic events, and there's various dollar amounts of insurance that a utility would have to carry. And the problem is that the value of the insurance would greatly exceed the value of the plant in certain cases. So what is going to be needed is a kind of equitable approach to this, looking at what makes sense for a smaller reactor in terms of both potential consequences in an accident, what the value of the plant is, et cetera.

The other is that the NRC, of course, collects its fees from utilities to fund something on the order of 80 percent of their budget. And it is a fixed fee for any size plant. And certainly, when you have a smaller output, that is going to be a larger fraction of your revenue.

So we came to a recommendation of a sliding scale based on power output. This would also include the process heat applications, where currently it is based on the electrical output, and we really need to be thinking of thermal output for both the electric and the process heat applications. So a sliding scale rather than a fixed fee is what we recommended there.

The other major area is in manufacturing. This is driven by the fact that the idea for SMRs is that they will be factory-produced and then shipped to a site. So, basically, this is a new business model, the factory fabrication versus site construction, a completely new way of doing business.

The problem is that the regulatory framework for what we are calling manufacturing license is weak at this point. So what we need is a framework put in place that addresses this new business model that the SMR vendors are proposing.

We also have to address the export

control issues. This becomes complicated, and multi-agencies would be involved, but if we are really envisioning a future where these reactors can be exported, then we need to have the regulations for export licenses addressed early on in the process to eliminate that uncertainty.

And then, finally, there will be a need to address the inspection and acceptance process. So, if a plant is manufactured at the factory, you would expect the inspection to occur there. Then, there is potential for redundancy in inspection and testing when it gets assembled. So this all needs to get worked through. And again, it really comes back to this factory fabrication and how that all comes together.

So, in summary, our Committee really provided a unique opportunity to bring the entire ANS community together from all sectors and to develop options for dealing with the generic licensing issues.

As I mentioned, we are just now completing our interim report addressing about eight of the 24 issues, and our work is currently slated to continue through June of next year, and we are hoping to develop papers on the remaining issues in that timeframe.

And thank you very much.

CHAIR DOMENICI: Who is in charge of this working group?

DR. KELLY: Philip Moore is the Chair, and I'm one of his Co-Chairs.

CHAIR DOMENICI: Is he here?

DR. KELLY: Philip is not here today, no.

CHAIR DOMENICI: What does he do?

DR. KELLY: He is a consultant. He used to work at Tetra Tech and is at a different organization now, but in the nuclear energy area.

CHAIR DOMENICI: Well, who does he report to? Who pays him?

DR. KELLY: This is all volunteer.

I mean the effort on the ANS is all volunteer.

CHAIR DOMENICI: Okay.

DR. KELLY: And we put the word out that we were doing this, and people volunteer their time. And of course, all the companies are supporting this because there is lots of interest in moving forward with this.

CHAIR DOMENICI: Right.

I want to go to the next witness, and then we can answer some questions.

Then, our next panelist is Mr. Ray Rothrock, partner in Venrock Capital.

Mr. Rothrock? You're the one that asked to stand up.

MR. ROTHROCK: Good afternoon. Thank you, Commissioners, for having me here today.

I really want to say, first of all, I welcome the Administration's, Secretary Chu's establishment of this Blue Ribbon Commission to address a very important issue, America's nuclear future.

I submitted a longer paper that substantiates and provides more evidence to what I am going to try to cover here in the next 10 minutes.

Just a little background about myself, I'm not from the nuclear industry now, but my name is Ray Rothrock. I'm a Managing Partner at Venrock. Venrock is a venture capital firm originally formed by the Rockefeller family. I've been doing this for 23 years. I've invested in 47 companies. So I guess I'm doing okay. In 2004, I established Venrock's energy practice, to begin to look into opportunities.

I started my career, though, as a nuclear engineer. I worked for Yankee Rowe, a 180-megawatt electric, by today's definition, small nuclear reactor, pressurized water reactor, built by Westinghouse. It cost about $50 million to build, standard fuel, 4.5 percent.

After that, I spent a year at

Exxon Nuclear before I went to the Silicon Valley to be an entrepreneur.

I presently serve on the Boards of the National Venture Capital Association, the MIT Visiting Committee for Nuclear Science and Engineering. I'm the Chairman of the Tri Alpha, a venture-backed nuclear energy company in southern California, and I have degrees from Texas A&M and MIT in nuclear energy and an MBA from Harvard Business School.

After conferring with Dr. Peterson a couple of weeks ago, I thought I might just give you a quick snapshot of venture capital. Venture capital's mission is to identify and sponsor entrepreneurs with world-changing ideas, and they have been doing it for a very long time. I daresay George Westinghouse and some of those old guys, Edison, and so forth, were some of the original people.

But, today, there are 794 venture capital firms in the nation. They start 2,000 companies every year.

In the last 50 years, venture capital has played a significant role in every technology industry except nuclear. As of 2009, these companies that were originally backed by venture capital were responsible for $2.9 trillion -- that's 22 percent of our GDP -- and those companies employ 12 million people, 11 percent of the private sector. America's venture capital is probably one of our greatest success stories.

And just to remind you of a few of those, some of these names up here you no doubt recognize. We are very proud that some of our little startup companies do, in fact, become very large, successful companies.

So, with that background as a prologue, the first thing I would like you to know, that many of us in the venture capital industry do support nuclear power, and we believe it is essential for America's future. I also want you to know that the venture capital industry wants to participate. I made a survey about three weeks ago of all the people I could get a hold of in my business just to find out if I could say that. Fortunately, and important to us, so do entrepreneurs. And the result is a steady stream of nuclear-based technologies that show up on our doorstep.

But we have a problem. The problem is that the federal agencies that regulate nuclear activities in the United States pose a significant barrier to startup companies, so significant that many of them never get a chance. Let me explain.

As everyone on this Commission knows, the two main agencies are the DOE and the NRC. Both of these are offsprings of older organizations that were created during the Cold War or at other times of crisis in the United States. Therein lies the root of the problem that these startups have with these agencies.

These agencies are primarily watch

guards, caretakers of our current nuclear infrastructure. To my knowledge, neither of these agencies is really an advocate for nuclear-generated electricity, and certainly neither has been a partner to the private sector in advancing nuclear power, certainly not in a meaningful way in the last several decades.

So, first, let me just summarize a little briefly about the DOE. In the last 18 months, the DOE, under the leadership of Secretary Chu, has made tremendous progress toward reaching out to young energy companies. We are very glad for that. There's a number of programs that have been touched on here today. We applaud this.

But as positive as that is, the DOE can only focus so much on nuclear energy. The DOE's budget proposal allocates just $900 million to nuclear energy. That sounds like a lot of money, and in my business that is a lot of money. But the DOE's charter is so broad, it will also spend $27 billion on other things.

So let me turn to the NRC. The NRC has no relationship, formal or informal, with the venture capital industry. Only recently have members of the NRC even begun showing up at conferences where these things are talked about.

Why the gulf? If you read the NRC's mission statement -- and it's on its website, it's very clear -- nowhere is there a mention of the generation of electricity by nuclear power. It is all about materials and public safety.

So, in my view, until young companies can engage with a regulatory body that is exclusively focused on promoting, supporting, helping bring to market a generation of nuclear-powered electricity, they are going to turn and do other things.

Uncertainty is a killer for this group. And just by the nature of this slide, these two groups, there's lack of focus right there staring you in the face.

So now it is my view that retooling the NRC or parts of the DOE to focus on nuclear-generated electricity would be very difficult, if not impossible. I say this because one thing I have learned doing venture capital for the last 23 years is organizational culture is crucial. It always is set early, and it is usually set in stone.

Even if we could change the mission statements and drive that through the organizations, I don't believe we can wait the decades it may take to transform those agencies to do what they really need to do for us.

This brings me to my first recommendation, regulatory recommendation, to the Subcommittee. I recommend that you create a new agency. I called it the United States Nuclear Power Agency. If you like that, I am happy to donate it to the Commission, and they can use it in their proposals going forward.

(Laughter.)

But, specifically, this agency should do four things:

It should focus on the enablement of the safe production of electricity from nuclear power.

It should provide an orderly review process and licensing process.

It should monitor the operations of the fleet, once they are up and running.

And it should be accountable for the safety for that fleet.

And fifth, I guess, is really educate the public on the science-based information.

The call to action for this agency is an urgent one. We have done this before. We did it with the AEC in 1947, the NRC in 1994, and then the DOE in 1977. We also did it with the Manhattan Project, when we were really threatened.

This is a big policy idea. I hope that you will give it some serious consideration.

So let me tell you why I think this will work. Actually, Dr. Peterson has already foreshadowed a bit of that.

In the venture capital industry, we work very closely with the FDA. It is a process that already does work. It can be done. This would be a good model for a successful partnership with the federal government and the private sector.

Part of our issue is the length of time it takes and the capital required. The FDA helps us with that. Its mission, the FDA's mission, taken from the website, is: to protect the public from bad pharmaceuticals, to assist in bringing worthy products to market in a timely manner, to monitor these products once they're in the market, and to inform the public with science-based information.

So let me illustrate with an eye chart here. This chart is an actual process. It is real data assembled by my healthcare team at Venrock, and it is based on experience. It is stepped. It has finite steps with finite years and finite capital. I am not going to take you through all of that. That's not the point of this.

What is the point of this is that not every drug submitted gets through the FDA. In fact, very few do. The yield is very small, but it is very efficient. It works well with the private capital sector and brings new products to market that benefit everybody.

When I was talking to my colleagues in the last three or four weeks, we could not find a process similar to this in our regulatory structure for nuclear.

I have two other recommendations that I think would help young companies bring nuclear innovations to market. The first is a carbon tax, and the second is an agency review process without charge-backs. Yes, I am a capitalist and I'm sort of a free-market capitalist, but I must say, as controversial as carbon tax is, I think it is very important, not just for nuclear, but for all alternative energy.

It would enhance the speed of innovation by drawing a bright line of economic standards by which all nuclear designs could be judged. This is crucial because economics drive venture capitalists. Economics drive entrepreneurs, not government-based incentives and not subsidies. It is a really crucial point.

My second recommendation is to eliminate the charge-backs. It is my understanding that when you submit something to NRC, you are billed on an hourly basis for the process of review. Well, in a five-year review process, that could be a lot of money. In fact, some survey did, it's anywhere from

$50 to $300 million. For a startup company, even $50 million additional burden to get going is an enormous cost.

So, in summary, I just simply want to say the DOE and the NRC, as good as they are and as much great as they have done for our country, simply are not, in my view, geared to support young companies in pursuit of nuclear power. The processes are too open-ended and too uncertain.

My experience suggests that changing the missions of these well-established organizations really isn't practical. Therefore, I would drive hard for a new agency to be focused exclusively on this urgent problem of generating electricity with nuclear power in America.

In addition, I would recommend the carbon tax at the source, not downstream, and with the elimination of the charge-backs.

In closing, I know that venture capitalists and entrepreneurs are the most optimistic people in the world. We're always long and we're always up and to the right. Nuclear power is essential for America's energy future. America once led the world. In the development and deployment of safe nuclear electricity, it can lead again.

Creating a new agency would send such an unmistakable signal to the rest of the world that we're going to lead this industry once again and clean up our carbon footprint, develop a secure sources of power, reduce the national debt and the political instability that comes from the purchase of foreign oil. I just can only emphasize how important I think that would be for this Commission.

I thank you for your time, and if I can be of any further service, I'm at your service.

CHAIR DOMENICI: Thank you very much.

Let's proceed to our next witness, the Director of Barclays Capital, Mr. James

Asselstine.

MR. ASSELSTINE: Thanks, Mr. Chairman.

First, I apologize for not having slides. I was on vacation last week when I got the invitation, but I will send you some written comments.

I will also send you my testimony from February of last year before the Senate Energy Committee, where I talked about financing requirements and the loan guarantee program. I think it still holds up pretty well.

As the Chairman said, I am a Managing Director at Barclays Capital. We are one of the leading arrangers of debt and equity financing for the electric utility and independent power industry.

This is a very capital-intensive industry. The lifeblood of this industry is the availability of financing on a continuous basis at reasonable cost.

CHAIR DOMENICI: Jim?

MR. ASSELSTINE: Yes?

CHAIR DOMENICI: Before you go on too far, could we establish that there is life in the private sector after working on regulatory laws for the United States Congress?

MR. ASSELSTINE: There absolutely is.

(Laughter.)

CHAIR DOMENICI: So how many years ago did you start with the --

MR. ASSELSTINE: It's a little over 20 years ago.

CHAIR DOMENICI: And what committee were we working on?

MR. ASSELSTINE: The Senate Environment and Public Works Committee.

CHAIR DOMENICI: And do you remember what law we were working on?

MR. ASSELSTINE: We worked on the Nuclear Waste Policy Act, among others.

CHAIR DOMENICI: Yes.

(Laughter.)

And look where you went, and look where I went.

(Laughter.)

MR. ASSELSTINE: Exactly. And look where we are on the waste problem.

(Laughter.)

I think you and I have gone farther than the waste issue has.

CHAIR DOMENICI: Yes, that's true, but not very far to go brag about.

Okay. Thank you so much.

MR. ASSELSTINE: Yes, yes. Certainly.

So this is a very capital-intensive industry. The lifeblood of this industry is the availability of financing at reasonable cost.

For that reason, this industry is predominantly structured as an investment-grade industry. So the bargain between investors and the industry is that investors are willing to accept modest returns for the money that they lend to the industry, and in return, they expect to take modest risk. So investors put a premium on long-term stability and predictability.

This is also an industry that builds assets that have a very long life. So the assets are operating for in excess of 30 years in many instances, which means that the industry also needs to arrange long-term debt financing. So financing is frequently 30 years in terms of term. So, again, that reinforces the need for predictability and stability over a very long period of time.

I am going to touch on the first-mover barriers, what federal actions are needed to make the initial group of proposed plants a reality, and then I will touch briefly on the price signals question that you raised as well.

For new nuclear, Rebecca put her

finger on it. The key challenge for new nuclear plant development in this country is financing, and that challenge is driven, in my view, by two considerations. No. 1, the scale of the projects relative to the size of the companies within the industry and, No. 2, the unique regulatory requirements that apply to new nuclear plants through the NRC licensing process, and the potential risks and uncertainties that that can pose to the investment.

In terms of the magnitude of the capital investment, it appears that, while the numbers are still moving around a bit as companies work on finalizing standard designs and negotiating equipment procurement contracts, that the first-movers are likely to cost in the neighborhood of $4 to $6 billion per reactor, when you add in not only the construction cost but also the financing and the utilities costs, and that would mean $12 to $16 billion if you wanted to build a two-unit site, which makes a great deal of sense in terms of operations of the plants.

If you look at the largest companies within this industry, Mike's company has a market capitalization of $27 billion. The Southern Company has a market capitalization of $31 billion. So, if you're building a $12 to $16 billion plant, you are making a huge bet in terms of the size of the company.

Compare that to Exxon-Mobil. Exxon-Mobil has a market capitalization of over $300 billion. They routinely do $10 to $20 billion projects, but the risk is on the order of 10 percent or 15 percent of their market capitalization or less than that. So the risk for the companies in this industry around building new nuclear plants is substantial.

Other risks, these are complex machines; large-scale construction projects. Because of the licensing requirement, the planning, licensing, and construction process is about 10 years to build a new nuclear plant, a very long period of time. And it is difficult to manage and fix costs over that long a time period.

The ability, as a consequence, of project owners to mitigate risk is more limited in terms of building a new nuclear plant than many of the other available alternatives.

As some of our previous speakers have mentioned, the new technology being pursued for the first-movers is evolutionary. My own personal view is the technology risks are not the dominant risks here. They really are financing.

The plants are similar in many respects to the existing technology. That technology is really quite mature. So I think technology risk is much lower around new nuclear investments, and that is really in contrast to something like clean coal and carbon capture and sequestration, where I think the technology risk is considerably higher.

We have a new, but untested regulatory process, as Rebecca described it. That process holds great promise to reduce financing risk, but we haven't proven that process yet by working the initial group of plants through the process. The risk and uncertainty will continue in investors' minds until that first group of plants moves their way through the process.

What investors want more than anything else is to see as many issues as possible resolved at the earliest part of the process, so that once you start to expend substantial amounts of money on the capital investment in the plant, the regulatory risk is relatively low or certainly bounded going forward.

What investors don't want to see is significant regulatory risk and uncertainty around the ability to bring the plant into operation after the capital investment has been substantially made in the plant.

The new process holds great promise to achieve that objective, but we need to demonstrate that through the early movers and mitigate the risk for the early movers as well.

The tools, in my view, to mitigate the risks around the first-movers are there. Many of them were included in the Energy Policy Act of 2005. Senator, you were instrumental in putting many of those provisions in the law, and others at this table I think worked on some of the efforts that led to those initiatives. I will hit just a few of them briefly.

The Loan Guarantee Program. In my view, the Loan Guarantee Program is a very important element for the first-movers. For the unregulated generation or merchant plants, as Mike described, I think the Loan Guarantee

Program is essential to obtain the debt component of the financing for the project, but it is also very beneficial for the regulated utilities, given the size of this investment compared to the size of the companies in the industry.

There have been a number of positive steps over the past two years in resolving some of the uncertainty around the Loan Guarantee Program. When the Energy Policy Act was first passed, the Department of Energy, in my view, did not have the project finance expertise it needed to process and evaluate loan guarantee applications. I think they do now, largely as a result of some of the effort over the past couple of years.

There were some technical problems with the DOE's implementation regulations for the Loan Guarantee Program. Those have also been fixed as well.

At the same time, progress has been extremely slow. It is almost five years since the passage of the Energy Policy Act, and to date, we have one conditional loan guarantee approval for a new nuclear plant, for the Vogtle units. And to me, that progress is much slower than what we need.

The existing loan guarantee capacity, as Rebecca mentioned, is currently at $18.5 billion. Roughly $8 billion of that is now committed to the Vogtle units. That leaves enough perhaps to provide loan guarantee commitments for one additional plant. We clearly need more than that. The $36 billion of additional authority that the Department has requested for the fiscal year 2011 budget is a step in the right direction. We may need more than the $54 billion, though, to deal with the first-movers.

The loan guarantee commitments also need to be workable and economic from the standpoint of the companies. So the arrangements have to work, and they also have to provide reasonable and economic financing.

I think there is a question in terms of how the Department is assessing and evaluating the subsidy costs for the loan guarantees. I think the Department needs to be realistic, both on the probability of default and on the likelihood of recovery, if the loan guarantees are really going to work.

Tax incentives you asked about. The Energy Policy Act provides production tax credits for 6,000 megawatts of new nuclear generation. That is a useful benefit. There have been legislative proposals to convert that to an investment tax credit that would accelerate the recovery by the companies. I think that is a useful thing to do. Also, accelerated depreciation would be a useful step as well.

The standby risk insurance provides protection for six units against regulatory delays and the costs associated with that. There is more protection for the first two units, less for the subsequent four.

I think expanding the level of protection would be useful there as well.

I personally support a number of the provisions that were included in Senator Kerry's and Senator Leiberman's climate change bill to help facilitate the development of the first-movers on the nuclear side. I think that is very useful as well.

Let me wrap up just by saying that, if you look at the zero-carbon or low-carbon energy alternatives in the power sector, virtually all of them face uncertainties and risks and costs that are higher than traditional fossil-fired generation. And if we are going to build more low-carbon or zero-carbon generation, as I think we should, then we are going to need some federal financial help and support to balance the playing field and make sure that those alternatives are going to be available. So a number of the elements that I have mentioned for nuclear I think would benefit from that as well.

Thank you, Mr. Chairman.

CHAIR DOMENICI: Thank you very much. Very good.

Now let's move on to our last one, Mr. Jack Spencer -- thank you for joining us -- a Research Fellow at the Heritage Foundation, is that correct?

MR. SPENCER: That is.

CHAIR DOMENICI: We are delighted to have you. We appreciate it.

MR. SPENCER: That is correct, and thank you, Senator, for inviting me here today, and I want to thank the Commission as well.

I am going to focus more on the fuel cycle part of the discussion today, some of the first-movers, some of what I feel the problems are, and perhaps some solutions.

Let me first just quickly talk about what I think is wrong with the current system. And in a word or a couple of words, it's the federal government. Theoretically, so long as the government is responsible for waste management, waste producers I believe have limited interest in developing a comprehensive solution. If the federal government is going to do it, then why should anyone else, essentially? And that is sort of the system we have today.

But, in addition to that, I mean we have experience now. Practically, the federal government has simply not fulfilled its obligations under the Nuclear Waste Policy Act. So, not only practically do I not think that our current system is credible, but practically it hasn't worked.

And what this system has done is it has created an economic disconnect between the waste producer's interest in a solution and what that solution actually is. Because you only pay a fee and you are not responsible for it if you are waste producer, then why do you care if you put it in Yucca Mountain or reprocess it or develop some other reactor technology that might give you more efficient waste product? None of those things really come into question. What really matters is that the federal government takes title of that waste in whatever form it is. So there is no economic incentive there.

There's no accurate price signals in the current system. You simply pay a fee. We don't know if we are going to put it in Yucca Mountain, shoot it to the moon, put it in the sea, let it sit there for 100 years or 300 years now, apparently. We don't know what is going to happen, but we do know that it is going to cost the mill. Well, that's not really an accurate thing, I think.

It undermines full fuel cycle solutions. Because the waste producer only cares about -- or they don't care about how that waste is produced; they only care about producing electricity. They're allowed to build business models around the fuel, the operations, but not waste management. So we are not developing a fuel cycle solution that considers the entire fuel cycle. So we need to fix that.

And because of that, what you end up with is stifling competition and innovation. If I am not responsible for how the waste is managed, then I am not going to get into the marketplace and try to drive that technology in one way or another because, frankly, it doesn't matter to me. I just need the government to take that waste from me.

What that ends up doing is it stifles competition, not just on the waste management side, but also on the reactor technology side. As we all know, your waste package, what comes out the back-end of the fuel cycle has a lot to do with how that fuel is engineered, what reactor that fuel goes into.

Once the waste producer becomes financially responsible or has a financial interest in that process, then they start driving competition on that front-end and on the back-end. That, then, starts to drive the competition all these different ways.

We don't need government bureaucrats to tell us what to do. The marketplace can tell us what to do, if we align the incentives properly.

So how do we fix these problems? Well, it's not, in my estimation, it is not a tweak, it's not fix the Nuclear Waste Policy Act a little bit here, a little bit there, a loan guarantee maybe, or something like that. We need real reform.

Now I am not saying I agree necessarily with Mr. Rothrock's idea of reform, but the totality of the reform I do agree with. And that is what I think we need.

I would start off with -- and I have a list of things here. They don't necessarily go in order. I think this has to be part of a reform package.

We have to empower waste producers to take responsibility for waste management certainly going forward. I think that that, to me, is the key to all of this. If we continue to leave the responsibility of such an important part of how we produce energy in this country, which is waste management, nuclear waste management, in the hands of the Department of Energy, we are standing at the threshold of a nuclear renaissance and we are never going to cross it.

We might build a reactor or three reactors or five reactors, but are we going to have the sort of nuclear renaissance, the burgeoning of technology that truly will allow us to change the world, that will bring electricity to not just me and you in America, but all across the world.

We hear about small reactors, big reactors, all these things. All these things I believe can be driven forward, but it won't be done by government. It has to be done by the private sector, and that won't be done until they are responsible for their own nuclear waste.

At the heart of this is we need to repeal the mill and introduce a fee-for-service system governed by the free market, but overseen by federal overseers. So the NRC or some derivative thereof, they would be responsible for overseeing it, but they are not going to make the decisions, DOE is not going to make the decisions on how to do it.

Simply put, if I produce waste, companies will come to me or I will go out into the marketplace to decide who and what way I want to manage the waste I produce. That doesn't mean the federal government doesn't have a role in transitioning to this system. Because I acknowledge that the way we do it now, and sort of the way I want to do it, you can't just snap your fingers and make it happen. There is a transition.

I think one role, one critical

role for the federal government to play in the near-term is to site and permit a geologic repository, not run it, but site it and permit it. I think we have a perfectly good one in Nevada; others disagree with me, although I don't know how many of them there are, but there are some or one who does.

Regardless -- I am getting off-track now -- we need a geologic repository. I think that it is a legitimate federal government role, given the history of where we have been in the last 50 years, to do that.

We need to create an entity to manage the geologic repository, including putting a price on emplacement. And that's really important. Notice I said just to manage the repository, not to manage nuclear waste. And I would prefer it to be a private organization, but if we want a federal organization, that's fine.

But by putting a price on geologic repository space, you then have the foundation on which to build a market-based system. Because geologic repository space at that point becomes a scarce commodity potentially.

We know that Yucca Mountain has a finite amount of space. We have a finite amount -- or we have nuclear waste. By creating a price for an emplacement, as that commodity goes down, the price for it goes up. As the price goes up, you then send the price signal into the marketplace that you need to do something else with your nuclear waste, or maybe you don't. Maybe you are willing to pay the higher cost. What I am saying is, once you put a price on that commodity, you then start creating incentives to do other things with the waste.

We need to abolish the Office of Civilian Radioactive Waste Management. In fact, I might put that one No. 1.

Then here's the other key: we need to require that all new plant permits include strategies for complete waste disposal as part of plant decommissioning. So, whenever you get your permit for a plant, you have to have a plan to get rid of your waste, and that plan can be changed over time, but you need to have a plan to get rid of your waste by the time, say within 100 years.

So the plan may be just to put it in Yucca Mountain or wherever the geologic repository space is or it might be to do other things, but you need to have a plan, not for the government to define that plan, and you have to have a way of financing it.

I think by putting something together like this, you then start to be able to build out from that and you are able to see how the government doesn't need to define whether we do this technology or that technology. The marketplace can begin defining those things for us and look at real solutions. Because at that point the ability for the waste producers to make money is hinged on the ability to get rid of the waste.

And I am confident enough in nuclear energy, the technology broadly, that we will come up with a solution to do that. It won't kill the industry. It will actually lift the yoke of this burden from the industry and allow it to go places we never thought it could.

Now the government's role in this would be to regulate, take final title of any decommissioned geologic repository. So, say we fill it up and turn the key. I agree that the government should take title of that, and I am even sort of okay with some basic R&D work, though I don't even think that is necessary. But I think we have a good foundation that we can reach into the government for that.

And with that, I will leave it there. Thank you very much for the chance to talk.

CHAIR DOMENICI: Thank you very much, Mr. Spencer.

Now I assume we all have some questions, and I am not entitled to go first because I excused myself a couple of times. So I will go after you all, and then I will catch on somewhere here. All right?

We will take Per first, and then you are next.

CHAIR PETERSON: Okay. Thank you, Senator.

I would like to start with just a couple of quick takeaway points.

John, I will look forward to seeing the report with all the detailed information that was learned from the SMR licensing, the SMR Special Committee. That will be helpful.

Ray, on the phased licensing process and the analogy with the FDA, that is also, I think, a helpful thing to think about in terms of structuring when it is you learn things.

I would like to start. I have got

I think two, possibly three questions, but a question for Jack Spencer.

You note that the repository operation and such probably is best done within the private sector. Another important question is, should it be treated as a natural monopoly or do we want to have multiple repositories? Well, the ideal of multiple repositories sounds a little bit ambitious.

(Laughter.)

So should it be structured like a natural monopoly?

And then, the next question would be the back-end of the fuel cycle, the other part is potential reprocessing. Is that an activity that should be treated as a natural monopoly or is it best treated as a commercial activity, if you could answer?

MR. SPENCER: I would look at waste management as your marketplace and geologic storage as one option in that marketplace and one type of reprocessing being in that marketplace. So you have waste management service providers competing for different things.

Now, regarding the geologic repository, I think starting off, yes, it would be a monopoly. You would have one geologic repository space, and it would be what it is.

Now I disagree, though, that it would be the only repository space because here's what I think would happen or could happen: as you have the repository space in place and people are using it, and it is done safely and there's economic growth around it, and it starts to fill up, and the price for that space increases significantly, you might have people down here at Carlsbad saying, "Maybe we can get in on this action," or somewhere else.

And then you start to build competition for repository space, but all that will be dependent on us having a buildout of nuclear power. I think that is one of the mistakes we have, is that there is sort of this assumption we are going to build all this nuclear power; therefore, we need all this waste management service.

I think that if we start off with Yucca Mountain, put a price on that, everything else will unfold from that.

CHAIR PETERSON: So, starting out, a geologic repository can be treated as a natural monopoly. The other elements probably should be treated as not being natural monopolies?

MR. SPENCER: They would emerge as the market would dictate.

CHAIR PETERSON: Okay. The next question relates to loan guarantees. And they are clearly an important part of the financing for first-movers.

Also, Rebecca's slide showing the magnitude of these project costs versus the capitalization of utilities is important as well.

One of the things I am curious about, the first point is that the loan guarantees are structured so that there is private equity at risk and, therefore, nobody comes into one of these projects with something they think is going to fail commercially because they will lose money to begin with, which is a better structure perhaps than a typical federal procurement contract, where you can make more money if you lose money.

So what I am curious about is, once we get experience from the first set of loan guarantees, that will address the problem that we face with respect to the first-mover risks, but it doesn't fix the problem that we face with respect to the fact that we have utilities in the United States which are highly fractured. In other words, we have a highly fractured-up utility industry compared to most countries.

So the thing I am curious about is, would it make sense at some point to make use of federal loan guarantees as a means to address this problem that utilities have a difficult time pooling risk? And if you were to set a credit subsidy fee specific to nuclear projects that covered the level of risk that we learn about over time, would this provide a mechanism in the longer-term to finance these projects for utilities?

Because, in essence, the other thing that loan guarantees do is they give you a mechanism to pool risk. Taxpayers really aren't liable for the federal loan guarantees. What is happening is that you are transferring risk over to students, and there's a whole host of other loan guarantees that also pay subsidy fees.

So I just would like to have a perspective about the potential longer-term role loan guarantees might play from the perspective of addressing the problem we face with financing these projects in the United States, given the structure of our utility industry.

Maybe, Jim, if you could start?

MR. ASSELSTINE: Sure, let me start, yes.

Well, your first point is absolutely correct. First, the law caps the maximum amount of the loan guarantee at no more than 80 percent of the cost of the project.

So, even for unregulated generation projects that would likely have more debt in their capital structure, you still would have a substantial equity cushion. The level of protection for the government is considerably stronger with a regulated utility because most regulated utilities are financed with a capital structure that is roughly half equity and half debt. So the amount of debt exposure for a new nuclear project for a regulated utility is likely to even be lower than that.

So that really got to my point earlier about the level of risk that the federal government was taking and how that tracks with the subsidy cost.

On your question of could this provide a vehicle for the longer-term financing, I think the answer is, yes, it could. I think you could make a good argument that the loan guarantee money or the government's commitment to support new nuclear construction through the loan guarantee project process could get recycled over time into future projects.

In fact, your risk around a new nuclear project drops fairly substantially after the unit enters commercial operation. We do have available traditional financing for largely nuclear unregulated generation companies where the assets are in operation.

So one option or one possibility might well be you recycle the loan guarantee money into new construction projects; you refinance some of that debt with more traditional debt after the units have entered commercial operation.

The other problem that you mentioned, the relatively fragmented nature of our industry, unfortunately, is a very difficult problem to come to grips with. It really relates to the fact that our utilities are regulated by individual states. The individual states really like having their utility headquartered in the state. They really want to maintain direct control over the utility, and regulatory uncertainty in terms of getting approvals for large-scale mergers within this industry has probably been the principal impediment to greater consolidation within the industry.

And unfortunately, I don't see that problem going away. We have seen some successful large-scale mergers, but they are very difficult. And regulators can either say no, because they want to maintain their own direct control over their local utilities, or, alternatively, they can demand that ratepayers be given all or most of the economic benefits from the merger, which takes away the incentive to consolidate within the industry.

CHAIR PETERSON: Okay. Any additional comments? Rebecca?

MS. SMITH-KEVERN: Yes, sir. The loan guarantees are the responsibility of the Loan Guarantee Project Office, which is outside the Office of Nuclear Energy. So they would be the ones that you should direct any further comment on that subject to.

CHAIR PETERSON: Okay. Thanks.

MR. ROTHROCK: The one comment I would make is that venture capital is largely an equity game. However, when we prove technology and prove products, that they work, and we need to deploy them, that is where the DOE has stepped in very nicely, mostly with grants. We have a number of companies that receive large grants.

And of course, everybody knows the Tesla story and the Solyndra story. These are huge grants as well as loan guarantees to build out these facilities.

So it is a very important element of our strategy when we start one of these projects.

CHAIR PETERSON: Could I have just one quick additional question, which is on a different type of subsidy?

In the commercial space launch industry at this point, we are actually seeing the emergence of very, very competitive capability to transport cargo into low-Earth orbit and strong incentives to get the government out of that business completely.

One of the things that DARPA did that caused that to happen was to finance these launch companies to launch test cargo up into space, and this provided a revenue stream early on in the demonstration process that allowed these companies to move forward.

I am curious if an analogous thing might be possible for new reactor and fuel cycle technologies where the federal government might, for example, procure test services for new fuels or coolants or materials or chemical processes as a mechanism to, again, incentivize the construction of the very first-mover plants.

Maybe, Jack, if you have a comment on that?

MR. SPENCER: Yes, just quickly, I wouldn't advocate something like that on the fuel side, but on the waste management side we have 60,000 tons of waste that the federal government currently is supposed to hold title to, which I think would provide a very good way to give some long-term contract, and to do it exactly with what you just said. So I think it is very analogous and possible to do.

MR. ROTHROCK: I think it is a great idea with particularly the SMR in mind.

I mean you can have military bases, others, you know, National Laboratories, could all be powered by small power reactors. That essentially provides a buyer for those products, i.e., electricity generated through nuclear power. So that actually is a good idea.

CHAIR DOMENICI: Thank you very much.

I told you that you were next, Allison, but I cheated.

(Laughter.)

I forgot about myself. So I am going to do two or three and then let you come next. Is that all right?

MEMBER MacFARLANE: I'll forgive you.

CHAIR DOMENICI: You will? You don't look too forgiving, but I'm going to do it anyway.

(Laughter.)

I want to tell the Commission I am

very pleased that the 2005 law is cited so much by so many witnesses about the future of nuclear power because another staffer, who is not with us today, and I did about 90 percent of the writing and drafting of it.

And I would want to say for the record that, between the passage of this bill and carrying it out in the White House under a Republican President with a Republican Secretary of State, that carrying it out has been absolutely abysmal.

As a matter of fact, what we are now doing with that law was not even intended. We went and wrote a law which did not require appropriations, and look at what we're hung up on. We are waiting around for an appropriation. It is really written literally where it is an Executive program. Congress gets involved if they want to by addressing the program, but not the loans. That is the way it is written. That is the only way it will work really.

Now it has been such a good incentive to move ahead, that it is working, in spite of them doing it wrong. The heavy, upfront payment was intended to make this part of a pooled process, the pooling of the contributions. As soon as you had a few of them out, you had a pool that would satisfy the debt, and, clearly, nobody would say that the government would have to pay, unless they all went bankrupt, the entire fleet of either small ones now or big ones that we are funding.

So, having said that, I want to move on to say to the gentleman who is a venture capitalist, I think whether we are able to carry out in any way what you recommended or not, this was an excellent experience for us who are working on this Commission. And for the little time you spent, I appreciate it.

The only way I see it, however, that we apply it is on the small modular reactors. I don't know how it could apply to the large $5-to-$6-billion plants. Maybe it could or maybe partial, and if we do it, we probably ought to make it available to whatever we state in the bill. But it is the small ones that we ought to be worried about now.

I want to say to John and Ms. Smith-Kevern, if we miss this one, we ought to all get spanked. The world is waiting to use small reactors. It is very hard to tell why now because they have been around for a while, but the United States of America has a chance to become the focal point and the manufacturing base for this product, not only here, but across the world.

They want them licensed here. But if we take too long in making it applicable, they are going to find another way to license them.

The people that are furthest along with using them are Americans who want them used here, but I guarantee you they won't wait very long. They will be owned by a foreign country or company or they will get out of here and do their work somewhere.

It should not take so long, Mr. Kelly and Department of Energy lady. It should not take so long to get what's needed to be done to make this program viable for the small reactors. They need changes. And whoever in this government is supposed to do that, shame on them if we don't get it done and offered to somebody in the next six to eight months. My bet is it's going to be six to eight years, and it will be gone. They will be announcing where they are going to be built, and here we lose another opportunity to manufacture.

End of statement on that one. I just wanted to make it clear because it does bother me quite a bit.

Now I would like to ask Mr. Asselstine, do you see the loan guarantees working better than they have in the past? Should it take as long now from what you know exists or from what you have heard and read about exists over there in the Department now?

MR. ASSELSTINE: I think we are farther along today than we were a couple of years ago, but I think the level of progress is still painfully slow. I think that we should see more commitments. If we are ever going to get to a significant number of additional reactors, I think we really need to get the first-movers moving along.

If you think about what has happened over the past couple of years, we have a little bit of time. As a result of the recession, electricity demand dropped by about 5.5 percent over the past two years. And prior to that, electricity demand was growing by 1.5 to 2 percent per year.

So, if you think about where we are today versus where we would have been without the recession, we are about 8 percent in terms of electricity demand down from where we otherwise could have been. That has given us a few years. So there's a little additional level of flexibility here, but it is time to get on with it. And having only one loan guarantee conditional commitment issued so far, to me is not great success after five years.

CHAIR DOMENICI: I am going to close with one further observation and question of our staff. Somebody mentioned, one of you -- I don't know which one -- or the previous testimony, that one of the companies involved as a potential first-mover had made a contract or signed a commitment to buy the big pot that goes in the light water reactors, had signed a contract to buy it -- was it you? -- to buy it from the only place that makes them, as I understand it, Japan.

Can you imagine, only one country makes the big bowl that is necessary for a nuclear power plant, and it's not us, and it soon may be Korea before it will be us, but it's Japan?

Now it was said that one of our companies contracted for that. I don't think it is the company that has anything to do with the current loan guarantee that was issued conditionally. I think it is one of the first-movers, but they don't have any agreement.

But look what they have done. It is such a slow process that they have purchased the pot which isn't needed for two or three years and stuck their neck out to pay for it. Because the system is so slow, if they wait until the end, they will get delayed another two or three years waiting for one.

They also have bought many things for the power plants before they have gotten loans because they are so anxious about the delays that are going to occur later.

I wonder if our staff could ask DOE if they have some kind of an idea of how much has been invested in that kind of thing in preparation for licensing by companies here in America, either American or otherwise. I would like to have that for the Commission, so we could see it.

With that, I think Allison was next.

MEMBER MacFARLANE: Okay. Thank you. Thank you all.

Two questions, starting off with an observation. And the observation is prompted by Mr. Spencer's suggestion that we put a price on the space in a geologic repository. I think this focus on space in a repository is partly a result of the Nuclear Waste Policy Act's statutory limit on the size of the repository, which is arbitrary, I might remind you.

I would like to also remind people that really nuclear doesn't produce much waste compared to most other. So really it doesn't. It is not such a big deal.

Yucca Mountain may have its own geologic limits, but that's Yucca Mountain, and not every other site would be the same.

And the space thing is also, you know, that's not really the most of the cost in a repository. The large chunk of the cost comes from planning and characterizing, not just drilling that extra few hundred meters. So I don't really know how you operationalize that.

And the other thing that I wondered about in your talk was that you said the federal government should be involved in siting the repository, and I don't see why. I don't see that that's consistent with the rest of your argument, but that's not what I'm going to ask you about.

I'm going to ask you about what we should do with the high-level waste in the nuclear weapons complex, and should that be entirely divorced from your suggestion?

Otherwise, you have private

companies that don't produce the waste carrying out the solution to that waste. So that's why we actually have the situation we have in this country.

That's one question. I have another question after that.

MR. SPENCER: Just quickly, on the space question, I use that sort of as shorthand. What I think is there should be a cost to put waste in Yucca Mountain, whatever that cost is. And in what I have written, I suggest there be a formula done, but there would be some cost associated with placing waste in Yucca Mountain. And if space doesn't decrease, you know, space isn't an issue, then the cost always will be what it is.

It is just that there is a pricing mechanism for putting waste in Yucca Mountain. Maybe I described it not as technically-accurately as I should have in the brief discussion.

For defense waste, I argue that

the Department of Defense would simply be a waste services purchaser. So they would pay Yucca Mountain to put their defense waste in there, just as --

MEMBER MacFARLANE: Yes, but some of that defense waste has big security implications. So I don't know.

MR. SPENCER: And that's part of the federal government's oversight role. I mean there are private companies who deal with all sorts of high-level waste right now. Our whole nuclear Navy program --

MEMBER MacFARLANE: Yes, I know.

MR. SPENCER: -- is privately run.

MEMBER MacFARLANE: Privately run but tightly overseen.

MR. SPENCER: So let's make this tightly overseen. I'm simply trying to find a solution to get this ball rolling, and the current one to me isn't working.

MEMBER MacFARLANE: Okay. The other question goes to Mr. Rothrock and Jim, and it has to do with the economics question. So I've got a number of little questions here.

One is, do you see a future, a large future, for nuclear power without some kind of carbon cap or tax? And how do these small modular reactors and other advanced technologies like, you know, these fast reactors that we were talking about this morning, fit into some of the stuff that you were talking about? And especially you, Jim, I would like you to look out a little bit further into the future.

MR. ASSELSTINE: Yes. Well, let me start, and I will start with carbon controls because my own view is it's not a question of whether; it's really a question of when.

And the interesting thing about the debate that has gone on over the past, say, 12 to 18 months or so has been that there's been relatively little argument about the end requirement, the requirement that we need to bring down carbon emissions by roughly 83 percent below 2005 levels by 2050. A lot of argument about the process we use and the milestones and the steps in between, but very little argument about the end objective, what we have to do if we are going to deal with the problem.

So there have been some interesting studies done about what this will require of the electric utility industry. Some of the work that I think is very interesting, and I talk about it a bit in the testimony that I will send you, is the work that has been done by the Electric Power Research Institute, the PRISM studies.

What they basically say is, if you are going to get to that kind of a reduction in carbon emissions by 2050, you need to do a lot of everything. You need to be aggressive around energy efficiency and demand response, so that you knock electricity demand growth down to below 1 percent per year. You need to build 100,000 megawatts of new renewable generation. You need to build 64,000 megawatts of new nuclear, and you need to aggressively move coal to carbon-capture and sequestration, if you are going to achieve those kinds of objectives. And that 64 gigawatts of new nuclear is by 2030, 2030, so 20 years.

And if you think the planning process takes 10 years, then that means that we have got a lot of wood to chop to get to that kind of objective. Can we get there? I think potentially you can, but that is an enormous, all of this together is an enormous financing challenge for the industry.

The total cost that EPRI estimates is $1.5 trillion to $2 trillion between now and 2030. That is a $100 billion investment per year. If you look at the run rate that we have seen over the past two years in this industry, that is about the existing run rate. And that, essentially, doubles the capital size of this industry by 2030. That is an enormous financing challenge for this industry. That is really the heart of the problem.

Can you build 64 reactors between now and 2030? Potentially you can, but it is going to be expensive and it is going to require a great deal of financing in order to achieve that objective, which is why I think the incentives, at least for the first-movers, are so critical.

And the same thing applies for the renewables. The experience we have around rewewables is pretty simple. To build that amount of renewables, you need a continuation of the tax support and the tax benefits, and the support in terms of power contracts at very attractive prices from state regulators as well.

We just did a large financing for a wind project in California, the first public style capital markets financing for a wind project since the credit crisis, 600 megawatts, so a very substantial project.

What drove that project was, No. 1, California's requirement that the utilities have to provide 20 percent of their electricity from renewables by the end of this year. No. 2, a very attractive power contract at $112 per kilowatt hour, fixed for 25 years. And No. 3, the cash grant program that, basically, gives the equity owners of that project all of their money back within 60 days of when the project gets built.

So you put those elements together, and you can build a very attractive wind project in a very reliable area northeast of Los Angeles.

So the project was a great project. It made perfect financial sense. Excellent investment on the part of the equity owners of the project. But it was the very expensive power contract, the strong support from State regulators, and the renewable requirement in California, and it was the tax benefits from the federal government. Those were the elements that make that work. Take those elements away; it's difficult to build new renewable projects in this country as well.

So it gets back to my point. If we are going to build these no-carbon or low-carbon alternatives, there's going to have to be financial support to make it work.

MEMBER SHARP: Could we a ask him to repeat? Could we ask him to repeat that figure on the cost? Did you say per-kilowatt hour or what?

MR. ASSELSTINE: Per-megawatt hour. Sorry. A hundred and twelve dollars per megawatt hour.

MEMBER SHARP: Per-megawatt hour, okay. So, compared to a new nuclear power plant, what is it?

MR. ASSELSTINE: If you look at some of the studies, if you look at NEI, the

Nuclear Energy Institute's financial model for a new nuclear plant, a new nuclear plant comes in in that $70-to-$90-per-megawatt-hour range, depending upon some of the underlying assumptions and whether it is built by a regulated utility or an unregulated generation company.

MEMBER SHARP: So this would actually be more expensive --

MR. ASSELSTINE: It would actually be more expensive.

MEMBER SHARP: -- if those estimates are right?

CHAIR DOMENICI: How does this come in versus other utilities? The consumers there in California, how much in excess of their neighbors, where you don't have this kind of a range?

MR. ASSELSTINE: Well, the power will be sold into the utilities. So it will be blended with the power costs from the other sources of generation.

And what, in my view, has allowed California to move aggressively on the renewable side is that much of the generation, the existing generation in California, apart from the four nuclear units that are very low-cost generators, are gas-fired generation. And the drop in natural gas prices over the past few years has brought electricity prices down, and it has allowed the State to continue to invest in renewables and other investments that they have been making and still keep the increase in the price of electricity at about the level of inflation.

MR. ROTHROCK: Could I add just a little piece to that?

So, on the carbon tax and the nuclear, you know, the real problem with burning coal or oil or gas is that we don't capture the total cost. In my prepared remarks that I guess you will get, I did a calculation of how much we have spent on OPEC oil since 2003 and the cost of the war. And it turns out to be $61 a barrel. We are paying about $73 today. So that's $130 true cost for that oil coming out of the Middle East.

So the problem is that is the wrong signal. Two summers ago, the price of oil was $140 a barrel and gasoline went through the roof, and people stopped driving their SUVs. So the pricing signal went to the right place.

So a carbon tax, in my view, would put the pricing signal at the right place. And that's why I think it's essential.

CHAIR DOMENICI: Let me suggest, sir, you might want to read a little more about this and see if a carbon tax, a CO2 tax, has that much effect on gasoline. It is my impression that a straight CO2 tax, even heavy amount in two stages, most of its effect is in the coal-burning states of America --

MR. ROTHROCK: Right, that's right.

CHAIR DOMENICI: -- and very little elsewhere, and very little on gasoline products from petroleum, from crude oil.

MR. ROTHROCK: Yes, I believe that's true.

CHAIR DOMENICI: So it doesn't do what you said.

MR. ROTHROCK: Right, but the nuclear and coal, those are competing technologies for --

CHAIR DOMENICI: That's why --

MR. ROTHROCK: I would just point out that the pricing signal is in the wrong place with oil.

CHAIR DOMENICI: That's why we get in trouble with it.

MR. ROTHROCK: Yes.

CHAIR DOMENICI: Because about eight or ten states -- and I hate to use it -- but they have been burned.

MEMBER CARNESALE: My understanding is it would take a very high carbon tax, higher than anybody is talking about now. You are not talking about replacing the subsidies by a carbon tax. You are talking about augmenting the subsidies or possibly reducing the subsidies in light of a carbon tax.

MR. ROTHROCK: The EPRI study that Mr. Asselstine referred to, the PRISM study, did some sensitivities on that. I don't recall exactly that data. It has been a couple of years since I looked at it. But it is like $20 and $40, and stuff like that, yes.

CHAIR DOMENICI: Who is next? Yes, you're next. Susan, do you want to go next?

MEMBER EISENHOWER: Yes.

CHAIR DOMENICI: All right.

MEMBER EISENHOWER: Yes. First of all, thank you very much for a terrific presentation. This is all very challenging, and using that word, I think Jim has already used the word "challenging".

I was rather knocked out by your observations about how many nuclear power plants need to be built and what the targets are by 2050.

This is a financing challenge, very clearly. I was wondering if, for this first question, the panel could say something about what earlier panelists have said, which is that the nuclear industry in this country is perceived to be dead. So we are really not talking about the renaissance. We are talking about a resurrection.

And in that context, what impact has, for instance, the termination of the Yucca Mountain project, what impact has that had on Wall Street and among the financial community, No. 1?

And some of the very out-of-the-box creative ideas that we have heard today, you know, this would require a general public opinion that the nuclear industry is not dead at the moment, but actually in a forward trajectory to make a creative idea like this happen, I think. What would be the transitional steps in a practical way, and what would you recommend to this Committee or this Commission, as we think about this?

I have another quick question after that.

MR. ASSELSTINE: Okay. Two points. I think, first, on "is the industry dead?", resurrection versus renaissance, I would say first it is important to keep in mind that we have 104 operating reactors.

MEMBER EISENHOWER: Okay.

MR. ASSELSTINE: And while we have not built a new one in this country in a good, long period of time, those 104 plants generate almost 20 percent of our electricity, and the operating record for those plants has been consistently strong and steadily improving over the past decade.

So, when investors in the financial community look at utilities that own and operate nuclear plants, increasingly, those assets are viewed as a very valuable asset.

MEMBER EISENHOWER: Okay.

MR. ASSELSTINE: And in fact, there are ways through power uprates to get additional capacity from those plants at very cost-effective prices. And that is viewed as a very low-risk way to add additional nuclear generation to the existing fleet.

When investors think about the waste issue -- I'm glad you asked me that question -- they think about it in two contexts. No. 2, the existing plants, and could the uncertainty create a disruption in the ability on the part of the owners of the existing plants to continue to run their plants?

I think, first, investors are relatively comfortable that interim spent fuel storage technologies is pretty straightforward and pretty low-risk, whether it's in pools or in casks.

No. 2, the NRC has successfully managed its waste confidence determinations. So the risk that the NRC will do something to disrupt the operation of the existing plants is viewed as relatively low-risk as well.

But investors talk a lot to the utilities, and they talk a lot to state rate regulators. And investors and those of us in the financial community share the industry's frustration that the federal government has failed to meet its contractual obligations under the Nuclear Waste Policy Act.

And I think it is less a matter of cost than it is what investors want to see, which I think is the same thing the industry wants to see. It is the federal government measure up to its responsibilities to take ownership and responsibility for the spent fuel. It was supposed to happen years ago now. It hasn't happened. And that's what they want to see, a manageable and workable plan for both short-term and long-term management of the spent fuel.

On the short-term basis, they think the federal government should pay for the incremental costs that the industry is incurring as a result of the government's failure to meet its contractual obligations, and that's happening.

But on an intermediate and a longer-term basis, they want to see a workable plan. Now some of the ideas that Jack mentioned are interesting and intriguing and potentially might work.

But I will go back to my theme of long-term stability and predictability. That's what investors want to see, and they want to see a relatively straightforward, low-risk path to the federal government carrying out its responsibilities. I think that is probably the preferred alternative.

And that probably involves a combination of paying for short-term spent fuel storage, whether it is at the reactor sites or in interim facilities; second, some steps on a nearer-term basis to start to move spent fuel away from the reactors and have the government take responsibility; and, third, a plan that will ultimately lead to a successful manner for handling spent fuel on a long-term basis.

MEMBER EISENHOWER: Any other comments?

MR. ROTHROCK: Yes, can I just make a comment?

First, on the Yucca Mountain, I think it is more important for the public perception that ripples its way back through the markets.

MEMBER EISENHOWER: Okay.

MR. ROTHROCK: I don't think any decisions we have made or people that I am aware of have made, that that's had much of an impact.

But there is a very optimistic

trend out there. As I mentioned, I'm on the MIT Visiting Committee for the Nuclear Engineering Department. I'm also very active at Texas A&M, and Per may be able to comment about Berkeley.

But there is a huge surge of students pouring into the nuclear engineering departments. Texas A&M's Department was 50 when I was there in the seventies. It is now 400 today. So there is an interest in and a resurgence of that activity. I think, in the meantime, I think MIT has only tenured one nuclear professor in 16 years, just because of the lack of research dollars and other things going on there.

So there is a resurgence, and I think part of the Commission -- and this is a little out of the purview, but I think education and driving it home at that level will finally, these people will become adults, they will become voters, and they will have a voice.

MEMBER EISENHOWER: Yes?

MR. SPENCER: Just quickly on this issue, I generally deny this notion that the U.S. nuclear industry is dead. I think it is very much alive.

Our commercial new plant industry is on life support, but if you look at the 104 reactors we have, they have been subjected to the marketplace largely without subsidy for the last couple of decades, and they're the most efficient, least expensive energy-producing machines man has ever created.

If you look at what's going on around the industrial base now, you have new manufacturing facilities in Virginia, Louisiana, across the country.

The educational growth, you just see it happening.

Our small modular reactor research and development that is going on in the private sector, the R&D that is occurring in our National Laboratories, in our federal laboratories, these are a real robust, very much alive nuclear industry.

What we need to do is to figure out how to focus it and get it to do all these things we want it to do.

MEMBER EISENHOWER: All right. I had one other really quick question, but I think it speaks to a very specific thing.

Jim, you had mentioned renewable portfolio standards, and this is one reason you could put together this astonishing project in California, especially when you think it isn't even baseload electrical generation. It may have a lot of wind, but it is still not necessarily baseload.

So, from what I understand, most renewable portfolio standards do not include nuclear, though some of them have a little fudge that says carbon-free in some vague way.

What would it do to the nuclear industry for that paradigm to be changed, where nuclear energy would actually be regarded as a renewable because renewable in this context really means carbon-free?

MR. ASSELSTINE: Yes, I think it would help because it would certainly open up an additional alternative. And it is especially true in certain parts of the country. I mean the Southeast is probably the classic example where existing renewable resources are really pretty limited. So, if you added nuclear in as part of a renewable portfolio standard, it would probably help encourage new nuclear development.

There was a fair amount of discussion around this in the Congress this past year, around a federal renewable energy standard, with some consideration given to including nuclear in it.

MEMBER EISENHOWER: Thank you very much.

CHAIR DOMENICI: Who was next on this side? Dick?

MEMBER MESERVE: Thank you, Mr.

Chairman. I have two questions.

Let me direct the first question at Ray Rothrock. You had indicated that the FDA might be a model for an appropriate regulatory structure and gave the new drug example, the phasing that occurs with a new drug example. I would like to challenge you a little bit on that.

The current licensing system at the NRC is phased to some extent in the fact that there are early site permits and certified designs before combined operating licenses, for the opportunity for all of those to occur, at least in principle, before any money has been spent in terms of actually putting stuff on the ground.

But, more fundamentally, I am not sure that the phasing at the FDA fits at all. I mean the first phase with the FDA is to find out if the dose information is appropriate, and then the whole series of escalating health studies with small groups at first to see whether there are adverse effects. You don't do the big study at first because you are afraid you will expose a whole lot of people.

So the phasing there is just actually part of a process that slows things down because of the fact that you need to go through a whole sequence of analyses. So I am not sure that this phasing concept beyond what we have fits the context in the nuclear industry very well. And I am curious as to what I'm missing.

MR. ROTHROCK: I don't believe you are missing a lot, except that, you know, the phasing there starts with basic science. And someone has an idea of how a molecule or a pathway in the body will achieve something. And you're right, they do do safety tests first before they actually do efficacy tests.

But, you know, there is sort of a parallelism in the science and to the question of, does it work; will the nuclear reactor actually work? Will it generate power? There may be some other key questions. For example, will it melt down if it lost coolant circulation? There could be lots of fundamental safety questions that could be answered very much upfront in the preliminary design work.

The safety question to the pharmaceutical I think applies to the site. Is the site a good site? Is it a relatively safe site? Can the safety things that have to exist to bring that plant online be provided there?

And then, finally, the dose. You know, if the drug is going to work, then we have got to know the plant is going to work at a much deeper level. This would be like the real code work, the computer code to validate the experiments, because you can't license a plant unless you can answer a lot of questions about various accident scenarios and transient scenarios, and all those kinds of things. We've got to have computer codes to do that because you can't go out and melt down plants; whereas, with drugs, you can actually go harm some living things, which they do.

So there is definitely a staged view, I think, in terms of the rigor, starting with the science, will it work, and then next to the safety, then to the dose, and then maybe, ultimately, the location. I think, actually, the geolocation can have a lot to do with it. I believe it was cited earlier about the transmission lines and those kinds of things which come in.

A lot of that could be done separately or at least at a level that could get venture capital to play a role in designing the plant to that next code level. I think it is a five-year cycle to sort of go/no-go. Whereas, in the FDA, if you have got something that doesn't work, you know generally very fast.

MEMBER MESERVE: Well, let me suggest that actually in the nuclear process it is not called phases, but, in fact, you do go through a sequence and you do get decisions as you go along. I think creating more hurdles you need to go over probably pushes in the wrong direction.

MR. ROTHROCK: Okay. One cultural comment. I did discover in my due diligence in preparing for here that, apparently, because of this demographic crisis that is going on, there is sort of younger engineers and more senior engineers or managers, and that sometimes processes are farmed out to the younger group and they will say this won't work or it can't work or we shouldn't investigate it. And that can stop the whole process.

I talked to two people who have lived with that, where something should have risen to a judgment, a management oversight level, that could have kept the process going, but, instead, it brought it to a dead halt.

MEMBER MESERVE: That is a

challenge when there's a large number of new employees that come in.

MR. ROTHROCK: Right. Right.

MEMBER MESERVE: I have a different kind of question for Jim Asselstine.

You know, the original argument, and the argument that is given by DOE for loan guarantees is that there is a need for the first couple of plants to get financing in place. And then, if those are successful and are built on budget and on time, that then just let the market take care of things thereafter, that it's only a first-mover consequence.

And if I understood you correctly, you are contemplating, in fact, we need some kind of a revolving system that will work on in perpetuity to be able to do the financing. That seems to me that is quite a big jump from the philosophy that has guided loan guarantees to date.

I guess part of the

justification for it might be that the companies, the capitalization, as Ms. Smith-Kervern had pointed out, the capitalization of the companies is small. But there certainly are opportunities as well for joint ventures of various kinds. You know, there are various ways you can work your way around those problems.

So let me just make sure I understood you correctly, that you want to move the loan guarantees into a realm that is somewhat different from what has been articulated to date?

MR. ASSELSTINE: I will describe need versus want. I think that the stronger need is just what you described, and it is probably more than a couple of plants, but it is the initial group of first-movers, where you would have the uncertainties around what the plants are going to cost, how the regulatory process is going to work.

There, I think that the loan

guarantee program really provides a very important underpinning for building those plants. It is not absolutely essential for the regulated utilities, I think, because the regulated utility borrows based upon its entire asset base, which includes substantial assets that generate cash flows now. It is possible for a regulated utility to build a new nuclear plant without the loan guarantee, but it is helpful there as well.

I think the need, though, is for the first-movers, to get that first group through the process, to demonstrate that the regulatory process is going to work relatively smoothly. It is not going to create big risks and uncertainties after the capital investment in the plant is completed.

And then, for some of those plants, if you are operating in an unregulated business model, I would argue it is more than a nice thing. It is probably a necessity.

The other alternative that I

mentioned is, is there the potential that you could start to recycle this money on a longer-term basis, given the magnitude of the financing challenge? That goes beyond the existing concept for sure. The existing concept is probably the first priority in terms of getting the first-movers going, but I do think there is a potential benefit, especially if the loan guarantee operates as we think it will, where the government really is not taking a lot of risk, doesn't incur any losses. Is there a benefit potentially recycling money, especially, again, perhaps for unregulated generators where the financing challenge is more difficult, where you are trying to finance on a single asset basis?

CHAIR DOMENICI: Dick, would you yield for a little clarification?

MEMBER MESERVE: Yes, of course.

CHAIR DOMENICI: Jim, would you tell us for the record, because I forgot, how much did we guarantee, six plants, for six plants?

MR. ASSELSTINE: Well, some of the provisions, the production tax credit and the standby risk insurance were really aimed at six plants. So the production tax credit was 6,000 megawatts. The risk insurance was for six units. So those were more specific.

The Loan Guarantee Program did not initially have a cap on it, although I think the concept was really get the first plants going and through the process, and then, once that is done, then some of the risks and uncertainties ought to decline. And I think that is correct.

CHAIR DOMENICI: Well, I now remember. We had a devil of a time getting everything for as long as we would like.

MR. ASSELSTINE: Yes.

CHAIR DOMENICI: And the Administration and the Secretary, then-Secretary, came up with this idea of administrative risk.

MR. ASSELSTINE: Yes.

CHAIR DOMENICI: It's brand-new and nobody has ever seen it, but they thought it was better than French toast. And we said, if you give us a little bit of ours, you can have some of yours. So we got it.

I don't know that anybody knows whether that will work or not, the risk insurance, but it is in there for only what?

MR. ASSELSTINE: For six units.

CHAIR DOMENICI: Six units.

MR. ASSELSTINE: That's right, yes. That's right. Yes.

The bigger constraint now, I think, around the Loan Guarantee Program is the appropriations restrictions.

CHAIR DOMENICI: Yes, which we never intended, but they are holding them to us, right?

MEMBER SHARP: Mr. Chairman, I don't have a question.

CHAIR DOMENICI: Oh, excuse me.

You're next.

MEMBER SHARP: I don't have a question, but I do have a comment, because there may be some confusion among us, and there is likely to be confusion among the audience observing this over what our mission is.

I think this is very valuable information, and we need to be aware of the context of how new nuclear may or may not develop and in what directions it may go. But my impression is we are unlikely as a Commission, and we have not been asked as a Commission, to determine what are the policy instruments either to advance or to slow up new nuclear power. And I wouldn't want all the observers who we want to hear from engaging in that debate, when I don't believe we plan to engage in that debate on this Commission.

I think that the goal is to understand what the impacts might be for how nuclear power develops in terms of how we must try to figure out how to manage the waste result.

CHAIR DOMENICI: Is that the extent of your comment?

MEMBER SHARP: That's it, Mr. Chairman.

CHAIR DOMENICI: Well, we are going to have somebody talk to us about that in terms of the small reactors. Is there no way that we can be the promoters of it because it has a positive impact on the nuclear tail-end of the cycle?

MEMBER SHARP: If there are things that we believe affect the result and the consequences of what decisions have to be made about waste, well, that is relevant, of course.

CHAIR DOMENICI: Yes.

MEMBER SHARP: But I would just suggest that I think we would be wise to keep our general focus --

CHAIR DOMENICI: Oh, absolutely.

MEMBER SHARP: -- where the charge was, on the nuclear waste. And I think we will be eaten alive in the broader debate, in which we will need a lot more witnesses than this to identify which of these things work well, which of them don't, which subsidy we like, which subsidy we don't like, how far should it go, how many plants should be available.

You have already conquered that yourself, but I am not sure the Commission can.

CHAIR DOMENICI: Didn't you have a lot of fun doing this this afternoon? Wasn't it fun?

(Laughter.)

MEMBER SHARP: Absolutely. I have loved that process for years.

CHAIR DOMENICI: Along with the drudgery, we've got to get a little bit of chocolate cake.

MEMBER CARNESALE: But it is an important point. To the extent that small modular reactors affect the waste problem --

CHAIR DOMENICI: Right.

MEMBER CARNESALE: -- that is germane.

CHAIR DOMENICI: Yes.

MEMBER CARNESALE: To the extent that they may be more economical, more popular, might serve more areas, that is not germane, as I understand it.

CHAIR DOMENICI: Well, they will affect the waste thing because spread the waste around, you know, little piles.

MEMBER CARNESALE: Well, I hope not.

(Laughter.)

No, but I mean it quite seriously. I think ours is not about first-movers. And I don't understand -- we can talk about that another time -- why that was framed about what we are doing. Our objective is supposed to be, if the nation chooses to pursue more nuclear energy, what needs to be done to make sure that the used fuel or waste, or whatever you want to call it, is handled safely, appropriately, and everything else that goes with it, and to make recommendations along those lines.

It is not, how do we make it more difficult for nuclear power plants to be built or how do we make it easier for more nuclear power plants to be built?

CHAIR PETERSON: I concur with Commissioner Carnesale. We are charged with looking out into the longer distance at technologies that might significantly affect the management of used fuel, which could include advanced fuel cycle technologies.

MEMBER CARNESALE: Yes.

CHAIR PETERSON: And in thinking about how those technologies might come into the market, we don't have a base of experience. So I would say that what is happening today provides some lessons about how one might do a better job in the longer-term, but certainly it is outside the scope of our Commission to take any position about the renaissance or not of nuclear energy. That is outside our scope. We are just trying to understand what is happening here.

MEMBER SHARP: Yes, and I wouldn't want from my raising the topic to be in any way reducing the importance of this, the value of it, or anything else. I am just concerned that a broader audience that might be, hopefully, watching this on the website and others may think the charge of our Commission is something different than at least what I understand, and I think most Commissioners understand, to be our charge.

We are trying to understand the context in which we are going to have to make decisions on waste.

CHAIR DOMENICI: What is the charge again?

MEMBER SHARP: It is about how to manage the nuclear waste or the spent fuel in this country.

CHAIR DOMENICI: All right. I think whether or not small reactors are part of the mix, or not, has some very significant role or plays a significant role on how the waste --

MEMBER SHARP: Well, that may be, and I am willing to entertain that idea. I just --

CHAIR DOMENICI: The small one that is talked about here, that they showed the picture of, it produces the same waste as the big ones, but it produces them at different places, wherever they are located.

And clearly, what is provided in the NRC and others about the waste is not going to be proper for the small ones, it is not going to be the same as we have in there for the regular ones. So, unless someone can tie them in, I don't know what we can say beyond the technology that --

MEMBER SHARP: Well, Mr. Chairman, that is why I asked the question in the previous panel about whether they saw there was any qualitative difference to what the requirements would be, either for storage, for disposal, or for transportation, if we went to at least two of the versions of the small nuclear. And the answer, at least in the earlier panel, was, no, there would not be, but --

CHAIR DOMENICI: But one of them said --

MEMBER SHARP: The light water, the two light water reactors; now the high-temperature gas reactor may well be different --

CHAIR DOMENICI: Right.

MEMBER SHARP: -- and it is also a different timeframe.

DR. KELLY: It is really a function of the uranium re-utilization. And

I think we heard that earlier today.

So the light waters are expected to have about the same as current generation light water reactors, but the other technologies, the gas-cooled or the thorium-based fuels, these types of things can get you significant --

MEMBER CARNESALE: Whether they are large or small --

DR. KELLY: Yes, exactly.

MEMBER SHARP: And that is very relevant to us. I don't mean to suggest that I don't think that's relevant. I do.

CHAIR DOMENICI: Okay, we are finished for the day here.

I don't want to talk about the small reactors anymore. I had a fun afternoon until you raised this subject.

(Laughter.)

And you became so blunt and difficult that, as Chairman, I'm declaring that this meeting is over.

(Laughter.)

MEMBER SHARP: I want to be sure you understand I like small reactors. Okay?

CHAIR DOMENICI: But it was over anyway. And I haven't given up. I don't think you're correct yet.

Thank you.

(Whereupon, at 3:32 p.m., the above-entitled matter went off the record.)

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