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U.S. Senate Date: Thursday, September 13, 2018

Committee on Environment
and Public Works Washington, D.C.

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ADVANCED NUCLEAR TECHNOLOGY: SAFETY AND ASSOCIATED BENEFITS OF
LICENSING ACCIDENT TOLERANT FUELS FOR COMMERCIAL NUCLEAR
REACTORS

THURSDAY, SEPTEMBER 13, 2018

U.S. SENATE

Committee on Environment and Public Works

Washington, D.C.

The committee met, pursuant to notice, at 10:03 a.m. in room 406, Dirksen Senate Building, the Honorable John Barrasso [chairman of the committee] presiding.

Present: Senators Barrasso, Inhofe, Wicker, Ernst, Carper, Cardin, Whitehouse, Gillibrand, and Van Hollen.

Senator Barrasso. Good morning. I call this hearing to order.

Before we begin today's hearing, I would like to say just a few words about America's Water Infrastructure Act.

This week, we were able to reach a bipartisan agreement with the House of Representatives on major water infrastructure legislation. America's Water Infrastructure Act answers President Trump's call to address our Nation's aging infrastructure.

In this instance, the bill fixes America's water infrastructure. It authorizes important projects to deepen nationally significant ports, upgrades levees and dams, maintains inland waterways and shipping lanes, increases water storage for the arid West, fixes aging irrigation systems, and enhances American-made hydro power.

This is also the most significant drinking water infrastructure bill in decades. It authorizes both new and existing programs that will give States and localities the ability to better address their drinking water infrastructure needs.

This legislation is especially important as Hurricane Florence threatens the East Coast. Provisions in this bill will boost flood control and increase water storage. Both are critical in the preparation for and response to major storms.

The House of Representatives plans to pass the legislation today. Then the Senate can take it up and send it to President Trump for his signature.

America's Water Infrastructure Act is a major infrastructure bill. It shows congressional commitment to heed the President's call for action on infrastructure. The next step is roads and bridges, surface transportation. I hope we can have the same bipartisan success when we address America's transportation infrastructure.

I would like to thank Ranking Member Carper; subcommittee Chairman Inhofe, subcommittee Ranking Member Cardin, the House Transportation and Infrastructure Committee Chairman Shuster, and Ranking Member DeFazio for all of their hard work on this bill.

At this time, I would like to invite Senator Carper for any additions you would make.

Senator Carper. Thank you so much, Mr. Chairman.

I want to second the words of praise you have offered for our colleagues in the House, for our colleagues sitting to our left and to our right, Senators Cardin, Inhofe, and all of our staff.

People at home say to me, and I am sure they do in your States as well, why can't you just work together? Why can't you work together and get something done? One of the most important

things we can do is create a nurturing environment for job creation and job preservation. A big piece of that is infrastructure. A big piece of transportation infrastructure is water infrastructure.

Thank you, Mr. Chairman, for your leadership. It has been a pleasure to work with you and your staff and our colleagues and their staffs in this effort.

As the Chairman mentioned, on Monday night, we were able to reach an agreement with our counterparts in the House to advance America's Water Infrastructure Act of 2018, which the Chairman and I co-authored, with the invaluable help of both the Majority and Minority staffs of this committee and our colleagues over the better part of this last year.

As you may recall, our bill was reported out of this committee unanimously 21 to zero a couple of months ago and, hopefully, it will receive the same kind of support in the House later today and then in the Senate in short order.

In the meantime, I would just like to highlight several especially noteworthy provisions in this bill that will make significant, positive differences in communities across the Country, including many in my home State of Delaware, throughout the Delmarva Peninsula and well beyond our borders.

For the first time in over 20 years, this bill reauthorizes the program that provides federal funding to States to help

clean up the water our families drink every day. The crisis that unfolded in Flint, Michigan several years ago was both tragic and avoidable. We have seen it play out since in far too many States across this Country.

In this bill, we are making clear that we have learned our lesson: that we need to devote more resources to the things that are most important, like making sure every parent, no matter what zip code they live in, can be confident that the water coming out of their tap is safe for their kids and them to drink.

Not only does this bill reauthorize this program, but we actually double its funding by fiscal year 2021 to the tune of nearly \$2 billion. Importantly, this legislation also allows States that detect contaminants in drinking water to assist residents who depend on private wells for their drinking water, rather than a public drinking water source.

For example, one in six Delawareans -- it is similar in other States as well -- depend on private wells for their drinking water. It is just not right that if contaminants end up in their water, through no fault of the citizens or the residents, those residents have to find a way to rectify that situation solely on their own. That is just not fair.

Our bill helps to change that by helping States test and treat underground sources of drinking water. Also, of note,

this bill authorizes investments in the waterways that keep this Country moving, from the Ports of Wilmington, to the Port of Mobile to the Port of New York and the Port of New Jersey.

Over 99 percent of U.S. overseas trade volume moves through waterways that the U.S. Army Corps of Engineers maintains. Think of that, 99 percent. Our bill will help to improve and expand the harbors, channels, and ports on which our economy depends.

With Hurricane Florence bearing down on the East Coast this week, I would be remiss if I did not briefly mention the important provisions in this bill that help coastal communities better prepare for increasingly powerful and frequently extreme weather events and enable those communities to rebuild more quickly after disaster strikes.

Most notably perhaps, in light of the avoidable devastation and tragedy we saw in the wake of Hurricanes Maria and Harvey, our bill allows for the investment of \$100 million in repairing drinking water systems damaged by storms. It creates new programs to protect this critical part of our infrastructure from damage due to extreme weather events going forward.

While President Trump has made waves this week with his comments about his "unsung successes" in Puerto Rico where nearly 3,000 of our fellow Americans apparently lost their lives, we have been working hard to pass a bill that will help

to ensure storm-ravaged communities actually have the resources they so desperately need.

There is much more in this bill that is worth highlighting, and I am sure there will be time to do so in the days and weeks to come. For now, I want to again thank our Chairman. I want to thank our colleagues, Senators Inhofe, Cardin and their staffs for their hard work throughout this process.

I also want to thank our friends in the House, Representatives Shuster, DeFazio, Walden and Pallone who were great partners in the House.

Together, we are stronger. When we are together, so is America stronger.

Lastly, I want to thank Secretary R.D. James, who sat right here where you sit Ms. Taylor several months ago for his confirmation hearing to be the Assistant Secretary to head the Army Corps of Engineers, who made this legislation a real priority and worked with the Senators on this committee to craft a bill that I think we can all be proud of.

I will end with an African proverb that I think is particularly relevant here: "If you want to go fast, go alone. If you want to go far, go together."

I think the fact that we have gotten a bill as substantive as this one to this point is proof that, in this Congress, if you want to get meaningful work done, you have to find some

common ground and find ways to work together. Kudos to everyone.

As we say in the Navy, when something good is happening, "Bravo, Zulu." Thank you.

Senator Barrasso. Thank you so much, Senator Carper, for all your cooperation. As you say, 21 to zero in this committee.

Senator Inhofe, as Chairman of the Transportation and Infrastructure Subcommittee, is there anything you would like to add?

Senator Inhofe. No, I don't think so, but one of the best kept secrets in America is that Oklahoma is navigable. The NCARNS, we have that reauthorization assured even though we have fallen behind. A lot of good things have not been mentioned that are a part of this.

Senator Barrasso. Senator Cardin?

Senator Cardin. I just really want to add that under Senator Barrasso's and Senator Carper's leadership, our committee worked very constructively on this. Under Senator Inhofe, as Chair and Ranking Member, that was tradition in regards to the WRDA bill and was continued. I just wanted to acknowledge that.

I also want to point out, Mr. Chairman, as I was walking over here, I was stopped by the National League of Cities. They wanted to lobby me on one issue, the passage of the WRDA bill.

I gave a copy of the letter to Senator Carper.

I also want to acknowledge Secretary James, when he was here, made commitments to visit some of our major facilities. He went to Poplar Island with me. His engagement on this process was extremely valuable.

This bill, the Water Resources Development Act, is going to be important for our Country. It is important in Maryland on the Chesapeake Bay and our efforts to clean up the Chesapeake Bay. It is important to Maryland for safe drinking water.

The work that is done here is important to help our schools and public facilities with the vast connections with regard to pipes that will no longer contain lead. It is important for our economy and what it does in regard to the Port of Baltimore and, by the way, other ports around the Country and around Maryland.

I am very proud to be a part of this and congratulations to all.

STATEMENT OF THE HONORABLE JOHN BARRASSO, A UNITED STATES
SENATOR FROM THE STATE OF WYOMING

Senator Barrasso. Thank you to all of you.

This morning we are here to examine the safety and other benefits associated with advanced nuclear fuels, known as Accident Tolerant Fuels, ATF. Accident tolerant fuels are for commercial and nuclear power plants. These fuels have the potential to greatly increase the safety and performance in nuclear reactors.

When loaded into a reactor, this technology would further protect uranium from melting if a plant loses the ability to cool the fuel. In the event of an emergency, accident tolerant fuels would provide significantly more time for power plant operators to prevent the release of radioactive material.

Following the 2011 disaster in Fukushima, Japan, Congress established a research program at the Department of Energy to encourage the development of accident tolerant fuels. Seven years later, we are approaching the critical window for nuclear power plants to reap the safety benefits of this technology.

In addition to safety benefits, accident tolerant fuels may also provide meaningful economic benefits. For example, these fuels would allow nuclear power plants to generate electricity more efficiently.

In doing so, the plants would reduce costs and generate

less nuclear waste. To realize these benefits, these fuels must be developed, tested, licensed and deployed commercially. The Nuclear Regulatory Commission plays the principle role in this process.

The NRC has the exclusive authority to license and regulate the civilian use of nuclear materials. Approving new nuclear fuels can be a challenge. The fuel vendors must first test the fuel in rigorous experiments. The NRC then must validate the results of these tests through highly complex computer modeling.

Finally, the NRC must ultimately license the new fuels for use in a power plant. The NRC, the Department of Energy and the nuclear industry are all carefully considering ways to facilitate this work.

In April of this year, the NRC Commissioners held their first public briefing on what needs to get done prior to licensing these accident tolerant fuels. The briefing helped the agency staff to develop a project plan for regulating accident tolerant fuels which the staff issued earlier this month. Yesterday, the NRC staff held a public meeting on the plan.

The private sector is also taking steps to deploy accident tolerant fuels on an aggressive schedule. Two fuel vendors have already loaded test materials into two reactors to gather critical data. This process is encouraging, though significant

hurdles remain.

One of the hurdles is the permanent closure of the Halden Test Center which Norway announced earlier this summer. Since 1958, the Halden Reactor provided critical information on nuclear fuels and materials to organizations within 19 countries, including the NRC, the Department of Energy and the American fuel vendors.

The Halden Reactor would have provided key scientific data to assess the performance of accident tolerant fuels. The NRC, the Department of Energy and the nuclear fuel vendors will now need to adjust their existing research plans. In spite of Halden's closure, it is imperative that the NRC and the private sector stay on schedule to make an accident tolerant fuel available commercially as soon as possible.

The operating licenses for over a third of our Nation's nuclear power plants will expire between 2025 and 2035. If accident tolerant fuels are available, American energy utilities will be able to reap their safety and economic benefits.

Such benefits may encourage utilities to make multiple, multi-million dollar investment decisions to extend the licenses for these nuclear power plants. These new technologies would also help keep Americans employed. That includes workers in my home State of Wyoming which produces more uranium than any other State in the Country.

Preserving America's nuclear fleet is not only good for the economy, but is also good for the environment. Nuclear power provides a source of clean energy to millions of American families and businesses.

As this week's issue of the Economist explains, "Some environmental activists don't like this source of zero carbon energy, but nuclear power still provides more than twice as much electricity globally as wind and 5.5 times as much as solar."

I look forward to the discussions this morning. I will now turn to Ranking Member Carper for an opening statement.

[The prepared statement of Senator Barrasso follows:]

STATEMENT OF THE HONORABLE THOMAS R. CARPER, A UNITED STATES
SENATOR FROM THE STATE OF DELAWARE

Senator Carper. I want to apologize to our witnesses. Normally, we call this a hearing and that is for us to hear from you. Please bear with us as you hear from us for just a few more minutes and then we will put on our listening ears.

Again, Mr. Chairman, thanks so much for convening this important hearing on advanced nuclear technologies, specifically accident tolerant fuels. I spent a lot of years in my life in the Navy and have a huge appreciation for nuclear on ships and submarines.

We were scheduled to have the christening of the USS Delaware, a fast attack, junior class nuclear submarine in Newport News this Saturday. It has been postponed until October for obvious reasons. I am one who fully realizes and understands the importance of nuclear energy done well and done safely.

I know my colleagues have heard me say this before, but I will say it again: I believe there are few environmental challenges more serious than climate change and the extreme weather associated with it.

Our leading scientific agencies, NOAA and NASA among them, tell us that climate change is causing rising global temperatures, rising sea levels, and extreme weather events. We

witness them almost every month, sometimes every week. Weather events, like the massive Hurricane Florence, is expected to strike the East Coast in the next few days and threaten the lives and well being of millions of Americans.

NOAA also tells us that extreme weather events that have cost our Country more than \$1 billion apiece have doubled in frequency over the past decade, with \$425 billion in losses occurring over the last five years. That is \$425 billion with a B. Think about that.

Whether it is a drought, a forest fire in the West, a hurricane or a massive flood in the East, climate change results in lost income, damaged properties, and sadly, in some cases, lost lives.

As we send up prayers for those who live in Florence's path and who are preparing for this massive storm, our Federal Government has a moral responsibility, not only to help our communities be better prepared for climate-fueled events, but to also address the root causes of these events.

To some of our friends across the aisle who are not yet ready to join the rest of us in addressing climate action, let me note that nuclear power is one of the many examples of how our Nation can combat climate change and, at the same time, grow our economy.

I want to say that again. Let me note that nuclear power

is one of the many examples of how our Nation can combat climate change and, at the same time, grow our economy. We can do both and we must.

When nuclear power is produced responsibly, it does not emit carbon and reduces our reliance on fossil fuels. Our Country can, and should, seize the opportunity to continue to use nuclear energy in our national energy mix.

Today, nuclear power provides about 20 percent of our Nation's energy, as well as 60 percent of our carbon-free electricity, but as we know, the nuclear industry still faces many challenges. We need to make sure reactors operate well and safely, especially in the event of extreme weather.

Take what happened in Fukushima: nuclear power can lead to devastating circumstances if the proper safety precautions are not in place, not up to date, or not adhered to. Safety must always be the top priority in our Country's approach to improving nuclear energy.

Today's costs for safety precautions at existing reactors, along with the costs of construction, operation and maintenance, can be expensive, especially when compared to the cost of other sources of energy, such as natural gas.

Fortunately, recent advancements in science allow us to build and operate advanced nuclear technology that is safer, cleaner and cheaper. If we are smart, we will replace our aging

nuclear reactors with this new technology.

As we will hear today, advanced nuclear technology could improve the safety and efficiency of our existing reactors over the next five years. Using new materials for our nuclear fuel rods in our existing reactors, known as accident tolerant fuel, may allow our existing reactors to avoid the danger of overheating during emergency situations, which is what happened at Fukushima.

At the same time, accident tolerant fuel could enable our current fleet of nuclear reactors to run more efficiently and, therefore, be more cost competitive. This is situation in which it is possible to do well and do good at the same time.

My colleagues know that I love win-win situations. They do too. Accident tolerant fuel has the potential to be a great win, not only for the fight against climate change and severe weather, but for industry, American jobs and, most importantly, the safety of the American people. We might want to think of this as a win-win-win-win situation.

As companies make advances in technology, we need to make sure that our regulatory framework keeps pace. The Nuclear Regulatory Commission, NRC, is still considered the world's gold standard of nuclear regulatory agencies.

As science and technology evolve, so too must the NRC. However, as I said before, we cannot afford to cut corners when

it comes to nuclear safety. I am interested, and I think we are interested, in hearing today how the Federal Government can ensure all the design testing needed is completed expeditiously to help inform the NRC licensing process.

We also need to make sure that the NRC has the resources it needs to review these new technologies and to ensure that our current nuclear reactor fleet remains safe.

In closing, let me add that I strongly believe Congress has a critical role to play in ensuring that our Nation invests wisely in clean energy. That includes finding ways to support advanced nuclear technologies which allow our reactors to be safer, more resilient and more efficient.

Advances in nuclear energy can help us attain a more nurturing environment for job creation along with cleaner air for our people and planet. That is a pretty good combination, one which most Americans would like to see us embrace, and I hope we will do just that.

Thank you so much.

[The prepared statement of Senator Carper follows:]

Senator Barrasso. Thank you, Senator Carper.

Senator Inhofe. Mr. Chairman, let me just make one comment.

We have been fighting this battle for a long time now. We know how long it takes new technology to move. When you look at countries like France and China, we have to figure out a way to do it faster. It is obviously an answer that we need to exploit.

Regretfully, we have all this competition for committees this morning and I will not be able to stay but to me, there is no single issue that is more important than this, further exploiting the opportunity to come up with the clean energy that is offered through our nuclear efforts.

Senator Barrasso. Thank you, Senator Inhofe.

Thank you and welcome to all of our witnesses. We are delighted that you have joined us here today.

Today, we are joined by Raymond Furstenau, Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission; Tina Taylor, Deputy Chief Nuclear Officer and Senior Director of Research & Development, Electric Power Research Institute; John B. Williams, Nuclear Fuels & Analysis Director, Southern Nuclear Company; and Dr. Christina A. Back, Ph.D., Vice President, Nuclear Technologies and Materials, General Atomics.

I want to welcome all of you. I want to remind you that your full written testimony will be submitted for the official

record. If you could, please keep your statements to five minutes so that we have time for questions.

I look forward to hearing your testimony if we could start with you, Mr. Furstenau.

STATEMENT OF RAYMOND FURSTENAU, DIRECTOR, OFFICE OF NUCLEAR
REGULATORY RESEARCH, U.S. NUCLEAR REGULATORY COMMISSION

Mr. Furstenau. Good morning, Chairman Barrasso, Ranking Member Carper, and distinguished members of the committee.

My name is Raymond Furstenau. I serve as Director of Nuclear Regulatory Research at the U.S. Nuclear Regulatory Commission. I am pleased to be here today to report to you on the status of our preparations to license the safe use of accident tolerant fuels.

I would like to start this morning by highlight the NRC's commitment to enhancing our regulatory infrastructure to facilitate the safe use of new technologies.

A recent example of success in this area is the licensing of new facilities using novel technologies for the production of medical isotopes, an issue of national interest due to periodic shortages of material used in diagnostic medical procedures for millions of Americans each year.

Accident Tolerant Fuel, or ATF, is another area of new technology, which has the potential to enhance safety at U.S. nuclear power plants. ATF is a category of new fuels for nuclear reactors that are expected to perform better than currently licensed fuels under transient and accident conditions.

The fuel in use today at U.S. nuclear reactors is comprised

of uranium dioxide pellets, encased in a metallic cladding fabricated from a zirconium-based alloy, and has remained largely the same over the past several decades.

This is a plastic mock-up of a fuel rod. This is a little bit larger in diameter than an actual fuel rod. Inside the rod, the cladding is zirconium-based. The uranium dioxide pellets are stacked in the fuel rods. In an actual reactor, active fuel is about 12 feet in length. There are hundreds of elements in a fuel assembly and about tens of thousands of these individual rods put into assemblies in a nuclear reactor.

We expect that near-term ATF designs, defined as the concepts that industry is pursuing for deployment by the mid-2020s, will have relatively small departures from today's nuclear fuel designs.

These small departures include specially designed additives to standard fuel pellets and robust coatings applied to the outside diameter of standard claddings intended to reduce corrosion, increase wear resistance, and reduce the production of hydrogen under high temperature, accident, conditions.

Nuclear fuel designs with an iron-based alloy cladding, also offering improved corrosion resistance, will likely be submitted for NRC review shortly following these near-term designs.

In the longer term, we expect ATF concepts to be submitted

for NRC review that utilize new fuel pellet materials that operate at lower temperatures than current uranium dioxide fuel pellets, and ceramic silicon carbide cladding, which potentially offers significantly improved performance under high temperature conditions.

We also expect solid-metallic fuel ATF concepts, which offer lower operating temperatures and decreased consequences of cladding breaches, to be submitted for NRC review in the years ahead.

To varying degrees, each of these ATF designs is expected to offer power plant operators more flexibility in how they operate their plants and provide more robust performance during normal operations and under potential accident conditions.

Most notably, ATF designs may enhance the ability to mitigate accidents due to the additional time available to plant operators prior to the onset of potential fuel-damaging conditions. ATF designs may also have the ability to reduce the amount of high-level waste produced by operating reactors by permitting extended operation of fuel assemblies in the reactor core.

While the NRC can license these new fuels under the current regulatory structure, we are taking steps to make our processes more efficient and effective. To that end, the NRC has developed a project plan to prepare for both near-term and

longer-term ATF designs. The plan addresses the complete fuel cycle, including fuel fabrication, fresh fuel transport in reactor requirements and spent fuel storage and transportation.

Throughout development of the plan, we have had extensive engagement with our stakeholders including licensees, nuclear vendors, industry groups, non-governmental organizations and our international counterparts. Some of those stakeholders are on the panel today.

The plan outlines a new regulatory approach to fuel licensing, in which the NRC is seeking engagement with potential ATF applicants much earlier in the research and development phase than it has in the past.

This early engagement is designed to identify potential safety issues as early as possible so they can be addressed and the overall safety conclusions can be reached within the planned licensing timeline.

Throughout our preparations, we are monitoring the Department of Energy's efforts to advance the technical basis of ATF, both experimentally and computationally. This close coordination is allowing the NRC and DOE to make progress despite the closure of an internationally-funded nuclear fuel and materials research facility, the Halden Reactor in Norway.

The NRC and DOE staffs are also working on ways to leverage DOE's testing capabilities and computational tools for use in

reaching our safety findings for ATF designs without compromising the agency's regulatory independence.

In conclusion, with the issuance of the staff's ATF project plan and the heightened engagement of nuclear fuel vendors, DOE, and licensees, I believe the NRC has positioned itself well to efficiently license the safe use of ATF.

Thank you.

[The prepared statement of Mr. Furstenau follows:]

Senator Barrasso. Thank you very much for your testimony.
We will have questions in a little bit.

I would now like to turn to Ms. Taylor. Thank you very
much for joining us today.

STATEMENT OF TINA TAYLOR, DEPUTY CHIEF NUCLEAR OFFICER AND
SENIOR DIRECTOR OF RESEARCH & DEVELOPMENT, ELECTRIC POWER
RESEARCH INSTITUTE

Ms. Taylor. Good morning, Chairman Barrasso, Ranking
Member Carper, and members of the committee.

My name is Tina Taylor. I am a Senior Director for
Research and Development and Deputy Chief Nuclear Officer at the
Electric Power Research Institute, EPRI. I am pleased to be
here today to talk with you about EPRI's research related to
accident tolerant fuels.

EPRI conducts research and development relating to the
generation, delivery, and use of electricity for the benefit of
the public. An independent, nonprofit organization, EPRI brings
its scientists and engineers, as well as experts from academia,
government and the industry, to help address challenges related
to electricity, including reliability, efficiency,
affordability, health, safety and the environment.

EPRI's members represent approximately 90 percent of the
electricity generated and delivered in the United States,
including all of the U.S. nuclear reactor operators.

For the past 30 years, EPRI has conducted research on
nuclear fuels for greater reliability, safety and performance.
Our research on ATF is focused on evaluating the safety and
economic benefits. While we are not currently developing any

ATF technologies, our work is informing strategic decision-making for ATF implementation.

Accident Tolerant Fuels have the potential to offer safety and environmental benefits with more resilient and efficient fuel and plant performance. Key improvements in ATF are higher melting temperatures, improved strength and toughness, reduced hydrogen generation, and better confinement of nuclear materials during postulated off-normal events. Additionally, ATF may also improve the underlying economics.

Getting these new technologies from design to implementation is challenging and involves the collaboration of many organizations. As you are hearing today, there is currently great collaboration underway between DOE, NRC, fuel vendors, industry, plant operators, the National Labs, EPRI and others.

EPRI's research is focused on how ATF performance improvements translate into providing more plant resilience to off-normal events and economic benefits during normal operation.

In 2017, EPRI performed an initial assessment of ATF. The performance of ATF concepts was evaluated for a number of scenarios. The work concluded that safety benefits do exist and vary among different ATF designs and plant designs.

Some ATF concepts may have mitigated the Three Mile Island II accident. Other accident scenarios we evaluated showed that

accident tolerant fuels have the potential to provide additional coping time.

A critical metric for decision-makers is ATF deployment timeframes. The sooner these ATF concepts can be deployed, the sooner the safety and economic benefits will be realized. Historically, the licensing of new fuels and cladding has taken upwards of 20 years.

EPRI is researching approaches that could shorten this timeframe. Advanced modeling and simulation with modern data collection methods may be useful to reduce the number of time consuming and costly tests that are needed. Development of new examination techniques may allow quicker results from the tests that are performed.

In conclusion, Accident Tolerant Fuels have the potential to provide increased safety margins over current nuclear fuels while also providing enhanced fuel reliability, improved economics and reduced high-level waste generation. Working collaboratively with the other stakeholders, EPRI will continue to conduct technical evaluation of accident tolerant fuels in order to provide information needed to establish criteria, provide safety analysis and identify economic benefits.

I thank you for the opportunity to testify this morning. I am happy to answer your questions.

[The prepared statement of Ms. Taylor follows:]

Senator Barrasso. Thank you, Ms. Taylor. I appreciate your testimony.

Mr. Williams.

STATEMENT OF JOHN B. WILLIAMS, NUCLEAR FUELS & ANALYSIS

DIRECTOR, SOUTHERN NUCLEAR OPERATING COMPANY

Mr. Williams. Good morning.

I am John B. Williams, Nuclear Fuels & Analysis Director at Southern Nuclear Operating Company and am a member of the Nuclear Energy Institute's Accident Tolerant Fuel Working Group led by Mr. Danny Bost, Executive Vice President and Chief Nuclear Officer of Southern Nuclear.

Southern Nuclear, a subsidiary of the Southern Company, currently operates six nuclear reactors in Alabama and Georgia. Southern Nuclear embodies the Southern Company's commitment to creating America's energy future by developing new products and services for the benefits of consumers through technological innovation.

As such, we are proud to be taking a leadership role in the development and testing of accident tolerant fuel.

It is an honor to appear before this committee to share my views on the benefits of accident tolerant fuels and how we can overcome the development and licensing challenges before us.

I thank Chairman Barrasso, Ranking Member Carper and the committee members for taking the time today to discuss this pivotal technology that has the potential to make our Nation's nuclear fleet more reliable and efficient, as well as enhance its safety.

America's nuclear power plants run 24 hours a day, seven days a week, providing 20 percent of the Nation's electricity and nearly 60 percent of its clean, emissions-free power. The nuclear fleet is a vital part of America's infrastructure and is essential to a reliable and resilient national grid.

The sustainability of the U.S. nuclear fleet will depend, in large part, on the industry's ability to innovate at a pace which will allow the plants to remain economically competitive with other rapidly advancing energy technologies.

One such innovation is accident tolerant fuels. ATF has shown potential to increase safety as well as increase fuel and system efficiency and performance.

The industry is making investments and moving forward. Southern Nuclear loaded two kinds of ATF cladding in our Hatch plant in February 2018. In 2019, three major fuel vendors in the ATF program plan to insert additional lead test assemblies in reactors operated by Southern Nuclear and Exelon Generating.

The results of this testing, and other tests being conducted by the Department of Energy, will provide fuel performance data and inform NRC fuel licensing. Testing and licensing activities will be conducted in parallel which will help to accelerate the development timeline toward the goal of beginning batch loads of ATF fuel in commercial reactors by 2023 and full deployment by 2026. This timing is intended to support

utility decisions regarding second license renewal.

The industry is appreciative of the NRC's plan to license fuel in an innovative way, while maintaining the highest levels of safety. Additionally, we are greatly benefitting from the DOE's National Lab's vast expertise and world class testing, modeling and simulation capabilities.

We are grateful for the close attention and support Congress has provided to ATF and for its recognition that this program represents the cutting edge of innovation that will help preserve America's technological and strategic leadership.

I, like you, Senator Carper, like win-wins. The successful development of accident tolerant fuel has the potential to provide a win for everyone, safety, the environment, consumers and plant operators by making light water reactors safer as well as more efficient and reliable.

In the process, if we develop a model for the transformation and modernization of the regulatory framework for nuclear plants, even better. For this to become a reality, we all, industry, regulators, the Department of Energy and Congress, must continue to work together without delay.

Thank you.

[The prepared statement of Mr. Williams follows:]

Senator Barrasso. Thank you so much for your testimony,
Mr. Williams.

Ms. Back.

STATEMENT OF CHRISTINA A. BACK, PH.D., VICE PRESIDENT, NUCLEAR TECHNOLOGIES AND MATERIALS, GENERAL ATOMICS

Ms. Back. Senators Barrasso and Carper, thank you for your invitation to appear. I am pleased to discuss our perspective on NRC's approach to accident tolerant fuel licensing.

We believe the NRC be prepared to license new fuels and claddings in the most timely way, while also ensuring that public safety is not undermined. To stop the premature shutdown of existing reactors, there is no time to waste.

In response to Fukushima, Congress in appropriated funding for the ATF program to support the development of a new breed of nuclear fuels and claddings that provide enhanced safety margins.

In the six years since, significant progress has been achieved by three separate industry teams supported by the Department of Energy. The Westinghouse-General Atomics team is one of those. We are pursuing a highly innovative ATF technology offering markedly enhanced safety features and significantly improved economics for existing reactors.

It will do so by allowing operation at higher power and for longer periods of time, thus enabling fuel recycles that can last as long as two years, compared to the 18 months now possible. Higher efficiency and less maintenance down-time, mean a more economically competitive reactor.

Consequently, many utilities have been strongly supportive of the development and expeditious deployment of these new fuels. GA is developing the cladding material, made from a novel advanced silicon carbide ceramic composite. The material, named SiGATM, was initially developed for our innovative Energy Multiplier Module, EM², an advanced high temperature, gas-cooled, small modular reactor concept.

We believe the future of nuclear energy depends heavily on developing the new materials such as those that survive much higher temperatures and are much less chemically reactive. That is why we have invested significantly in SiGATM material that safely can withstand temperatures of up to 1,800 degrees Celsius compared to metal claddings, such as zircaloy, that start to fail around 800 degrees.

I am holding an example of a rodlet that will be inserted next year into the Advanced Test Reactor at the Idaho National Lab. It will undergo irradiations that will provide important data on the cladding performance in realistic reactor conditions.

Incredibly, we make this cladding starting from silicon carbide fiber. It is very flexible. The process we use creates a kind of rebar into our material, transforming it from a brittle ceramic into a fracture-tough material. Our results are very promising and if they hold up, we will revolutionize the

industry.

Ultimately, the same technology can be used in our EM² and other advanced reactors. Whether for ATF or advanced reactors, we must modernize our licensing processes before the reactors are lost.

I view the ATF licensing as a key step towards establishing good practices for advanced reactor licensing. Modernization means we will develop new and accelerated NRC processes without compromising the NRC's high safety standards. We must do this quickly.

For example, GA is developing a new methodology that we call Advance Fuel Qualification, AFQ. The idea, supported by DOE for funding, is to leverage computer modeling and simulation to reduce the amount of data needed for licensing.

Regardless of whether this methodology or another is implemented, early and sustained NRC involvement is key. I am pleased to see that the NRC draft project plan for the ATF recognizes that the past licensing path, which relies primarily on empirical data for fuel performance, cannot be the way of the future.

Good progress in licensing has been made for near-term technologies such as the metal-coated claddings but we also have to achieve the same progress for our long-term technologies, the more innovative technologies like ours that will require

different assessments and regulations.

Since our SiGATM cladding is a ceramic and not a metal, this revolutionary technology will be delayed until the NRC develops technical acceptance criteria for licensing approval. The good news is that the longer term technologies may be available only two to three years after the near term if the NRC moves promptly on them.

We welcome engagement with the NRC so that we can assist them fully in understanding these materials so they can develop their validation plan and license in the most timely and safe fashion.

We have been using technologies in the nuclear industry that over 60 years old. It is time that we adopt new technologies, particularly those from materials sciences, not because it would be nice to have, but because they are needed for our industry's survival.

To be successful, the NRC, DOE and industry must work closely together. If we do, we will find new ways to produce nuclear energy safely, cleanly and at a much lower cost.

We hope this committee will use its oversight and legislative powers to ensure that the NRC continues to design the new procedures it needs to license new technologies. Please visit San Diego. Seeing the fabrication in action will bring home to you the clear example of how ingenuity can transform the

nuclear industry.

I thank you for your interest and support.

[The prepared statement of Ms. Back follows:]

Senator Barrasso. Thank you for your testimony. There is an open invitation now to San Diego. Thank you. I appreciate the testimony from everyone.

Mr. Furstenau, let me start with you.

Hurricane Florence is rapidly approaching the southeastern United States. One of the news stories today showed a map of North Carolina where the nuclear power plants were by the coast.

Will you update us now on how the NRC nuclear power plants and other NRC licensed facilities are preparing for the hurricane?

Mr. Furstenau. Thank you for the question, Senator Barrasso.

Based on available information, the impacts from the storm surge, winds and flooding at Brunswick and other plants in Florence's path will fall well below the plant design parameters. One reactor at Brunswick has started shutting down. Both Brunswick reactors are expected to be fully shut down hours before hurricane force winds could affect the site.

All U.S. nuclear power plants have the additional resources like pumps, generators and procedures required by the NRC after the Fukushima accident to maintain key safety functions during any severe event like this. Available information indicates that the plants can remain safe during the storm without the post-Fukushima equipment.

NRC inspectors are at every U.S. operating power plant, following normal agency procedures. Additional inspectors have been dispatched to the plants in the storm's path. The NRC will continue to observe the plants' response in the storm and its aftermath.

Senator Barrasso. We appreciate that update. Thank you. It is very reassuring.

Moving to the topic of discussion today, last year, the Nuclear Regulatory Commission established an Accident Tolerant Fuel Steering Committee. The steering committee just issued the first version of a project plan for the licensing of the accident tolerant fuels.

The plan serves as the strategic document for NRC and the private sector to make accident tolerant fuels commercially available. The plan includes multiple benchmarks and goals for timely action by the NRC staff.

Do you believe the NRC can adhere to the scheduled outline in the steering committee's plan and will you commit to notifying the committee if the NRC is unlikely to achieve its benchmarks?

Mr. Furstenau. Mr. Chairman, the NRC is committed to that plan and we do believe we can meet the milestones in that plan. Of course, it is a living document and I think the other panel members would agree that if there are things that come up during

the progress on the plan that need to be changed, we would do that with full and open participation of the stakeholders.

Senator Barrasso. Thank you.

Ms. Taylor, the Electric Power Research Institute is uniquely positioned as an independent, non-profit organization, to collaborate on accident tolerant fuel research. We appreciate that.

Can you explain how your organization's independence can give policymakers and the public greater confidence about the research the NRC, the Department of Energy and commercial fuel vendors are conducting on accident tolerant fuels?

Ms. Taylor. Yes. An example of that would be the work we have done initially to assess the potential ATF concepts where we have used modeling capabilities we have to model how those fuels would perform during normal operation and during accident scenarios.

That provides a base of information that is non-biased that people can use for decision-making.

Senator Barrasso. Thank you.

Mr. Williams, can you explain how the economic benefits of accident tolerant fuels could encourage utilities to renew licenses for existing nuclear reactors?

Mr. Williams. Yes, sir. As utilities reach the end of their operating license, they are beginning to evaluate whether

or not to make the significant investment of whether or not we will renew our operating license.

There are a number of factors involved. One is the cost of the energy that we will bring to the market and the available market for that. If ATF is able to provide the economic benefits it shows then it makes our plants more effective and improves the business case by which we would make those decisions.

Senator Barrasso. Dr. Back, General Atomics is developing a particularly innovative accident tolerant fuel. I understand the new fuel would be suitable for today's commercial light water reactors as well as tomorrow's advanced reactors.

Will you describe how this fuel differs from accident tolerant fuels that other commercial vendors are currently developing?

Ms. Back. Thank you.

The material we are working with is actually something you could not have made 20 years ago. This is a ceramic, like your coffee mug, which is very good at retaining the fuel. In this particular case, because we have the fibers inside, it acts like rebar cement. That is what we call fracture tough.

Very important in these future scenarios to give added safety margins is it goes up to very high temperatures. In fact, this material does not melt. That is why the temperature

difference is so vast between metals and ceramics.

Also, it retains re-coolable geometry. This fuel, in an accident, would not breach in the same way that a metal would. Different metals have different behaviors than ceramics. These materials can increase the performance.

Senator Barrasso. Let me follow up with that, if I can, the difference between near-term and long-term. How is the NRC's project plan addressing both, the near-term use of accident tolerant fuels as well as longer term proposals like those that General Atomics is developing?

Ms. Back. The plan has been very nice because it lays out by category, for instance, thermal hydraulics, burn up and so on. The key difference, I think, is that for many of the near-term concepts, zircaloy is still the metal cladding that is providing most of the function. There is a coating on top to, for instance, decrease the hydrogen generation.

Fundamentally, that does not change the properties of the cladding to allow it to have a higher margin in safety. The fact is that we go up to much higher temperatures, can have a coolable geometry, have orders of magnitude less in hydrogen generation, and the corrosion is much different. In Fukushima, there was an exothermic reaction which is what caused the hydrogen production. That would not happen with this material.

Those are the kinds of things that now require different

fuel performance calculations because the material is fundamentally different. Those calculations have to be included in the regulations and taken into account. The full benefits will actually be seen there.

Some of the early calculations now do not fully take into account some of these benefits. That is why there is a second generation of the EPRI report that will be coming up. I think those things will be reflected much better as we are able to incorporate these into the fuel performance calculations.

Senator Barrasso. Thank you so very much, all of you.

Senator Carper.

Senator Carper. When my sister and I were little kids growing up in Danville, Virginia, sometimes our family listened to the news on ABC radio, a guy named Paul Harvey. We were just little kids. When he finished the first part of his news, he would say, page two and go on to the rest of the news and finally, page three.

I want to ask you about page two. There have to be some smart folks around this Country who are looking at this technology, accident tolerant fuels, and also what Christina talked about over at her company, and they are saying that makes no sense, that is not very smart, that is not a good investment of taxpayer dollars. Why would we do that?

I want to ask one or more of you to explain those arguments

against going down this path and then rebut them. Lay out briefly the arguments against this technology and rebut them, one or more of you, please. I do not care who goes first.

Ms. Taylor. I don't know that I can fully address that question. However, one concern certainly is the ability to develop and license these quickly enough to make a difference in the existing reactor lifetime plants are currently licensed to. There is concern that can these be licensed quickly enough?

Senator Carper. Others, please? Mr. Williams?

Mr. Williams. Another concern is that it is going to increase the cost of the fuel that we purchase for our plants as we deploy new technologies. That is why the safety and, therefore, the economic benefits analysis are important as we try to make the business case that this is in the best interest of our customers and results in an overall lower cost.

Senator Carper. Thanks. Ms. Back?

Ms. Back. I would like to point out that we are in a new world where materials are understood better. We can make parallel improvements and calculations can be taken into account to really leverage the amount of data to help us understand the behavior of the fuel.

The concern is that it will take too long to incorporate these new materials. Really, the rebuttal is that if we do not do this, we will not be able to make cost competitive nuclear

energy.

We will not be able to take advantage of new engineering and science that has happened that, for instance, changes your phone from something that used to be a rotary dial that is now in everybody's pocket which is really a little computer.

There are advantages in new technologies that are worth waiting for and worth investing in. In this case, because we can do parallel advances in the modeling, licensing and technology, all of these can come together if we work well together.

Senator Carper. Thank you.

Secondly, I want to address workforce. I will start with you, Mr. Furstenau.

The NRC will recruit the talent it needs to keep up with the new nuclear technology. What more could or should Congress do to help overcome any skill gaps you are aware of?

Mr. Furstenau. Thank you for your question, Senator Carper.

I think the workforce planning is very important, how are we going to be ready for this in the future? I agree.

At the NRC, we have been doing strategic workforce planning exercises to adapt to that with an aging workforce in our own agency and the outlook ahead for what may be coming down the line with accident tolerant fuel or other advanced reactor

concepts. We need to recruit that talent.

We are doing, like I said, strategic workforce planning exercises. There is the Integrated University Program that NNSA, DOE, NRC and Duke do complementary work on. Those types of activities are important to grow that workforce in the future.

Senator Carper. Thank you, sir.

Dr. Back, as someone who works for a company that is a client of the NRC, do you feel the agency has the necessary workforce to review the new technologies that you described to us today or does more need to be done?

Ms. Back. I think it is a challenge, because the new material and new technologies require new learning, but there is a very eager and young group of engineers, nuclear engineers and scientists that really do want to make a difference to clean energy.

I think the workforce is eager to try and engage and put together a licensing plan as well as develop the technology. The skills that are needed I think can be found as long as we work together to understand the material and to show the data. The NRC has to make their independent judgment of the data.

We need to put together plans that take into account these different behaviors. I think those are challenging questions that the younger generation is eager to adopt and get involved

with. I think there will be people who can fill those skill gaps.

Senator Carper. When I come back, I would like to ask some questions about Halden, the test reactor and how the U.S. Government is going to fill the gap when Halden is no longer an option. Thank you.

Senator Barrasso. Senator Whitehouse.

Senator Whitehouse. Thank you, Chairman.

Welcome, all of you, and thank you for being here.

I am very interested in the prospect of advanced reactor concepts that hold the promise of being able to repurpose spent nuclear fuel. At present, we really do not have a plan for the spent nuclear fuel stockpiles.

There are technologies emerging that would appear to be able to, and are, in some cases, asserted to be able to repurpose that stockpile and make some positive use of it. For instance, General Atomics has a design for an energy multiplier module that explores this potential.

I am wondering if I could get your comments on how far we are in that direction and whether there are some early positive indicators about nuclear technologies that could repurpose existing nuclear waste stockpiles?

Why don't we go right across?

Ms. Back. Thank you for the question.

The EM² Energy Multiplier Module is actually designed so that it can burn light water waste as well as its own waste. We really do not look at it as waste; we look at it as spent nuclear fuel.

In the case of light water reactors, 95 percent of the material that is in the fuel rod is actually Uranium 238, which cannot burn. That is why you need an advanced reactor, in this case a fast reactor, so that you can burn that material.

In that case, you can take a light water reactor core, do a process to remove the fission products, and then reform that fuel and, in a sense, recycle it. It is done with a process which is not the conventional reprocessing. It is a dry process.

That process has been demonstrated. Canada and Korea have different aspects of it that have been successful. I think this can be incorporated so that we generate new fuel cores for EM² or some advanced reactor. It burns over its period of time, recycles and over some 200 years, you can get rid of all of the geological waste that would be in the light water reactor spent fuel rod.

Senator Whitehouse. Mr. Williams, do you have anything to add?

Mr. Williams. At Southern Nuclear, we are obviously paying attention to the advanced reactor technologies and staying

abreast of the claims of those. At this time, we have not pursued any action there.

Senator Whitehouse. Ms. Taylor.

Ms. Taylor. I cannot speak to any specific design but I will say that in the advanced reactor space, similar to the accident tolerant fuel space, many companies are innovating with different approaches. It is an area where we see a lot of early career people contributing as well.

Senator Whitehouse. Mr. Furstenau.

Mr. Furstenau. The NRC is open to review new and innovative designs as vendors prepare for that.

Senator Whitehouse. In the committee, we have cleared the Nuclear Innovation and Modernization Act, which is now running hotlines for passage on the Senate floor. Senators Barrasso, Inhofe, Crapo, Booker and myself are the original co-sponsors.

Senator Crapo and I also have the Nuclear Energy Innovation Capabilities Act which has passed the Senate by unanimous voice vote.

The first bill would reform the NRC licensing process to open it up to more technologies than the light water reactors. The second would help facilitate collaboration between the private sector and our National Labs towards the development of these technologies.

We also just passed in the Senate a third bill that I did

with Senators Crapo and Alexander that would allow and fund the Department of Energy to use spent Navy fuel for research in these advanced nuclear reactor technologies.

Do you see those three measures as positive steps in freeing up the regulatory authority and the research capability to move forward in this space of potential reactors that could use our existing nuclear spent fuel stockpile as fuel, recycle or reuse it?

Start the other way with Mr. Furstenau first and we will go across.

Mr. Furstenau. Senator Whitehouse, I really cannot comment on pending legislation from an NRC standpoint.

Senator Whitehouse. Fair enough.

Ms. Taylor. We are seeing some very positive results with the innovative companies working together with the National Lab capabilities to move a lot of technologies forward.

Senator Whitehouse. I think actually we are seeing kind of a signal response thing. The National Labs have stepped forward more. Seeing this legislation going forward and seeing its support, they are actually a bit ahead of the actual bill which is a good thing. It is a good signal response.

Mr. Williams. Yes, sir, absolutely. Southern Nuclear believes that any legislation that promotes innovation in nuclear is a positive thing and will benefit the industry

overall.

Ms. Back. I absolutely think it helps because by nature, nuclear energy needs to be conservative because we need to be safe and we want to keep the gold standard of the NRC.

That means that we have to change the regulations and the ways we assess materials and develop the processes to meet the need of bringing in new technologies. That means looking at how we characterize the materials, developing new regulations which are not now based on a deterministic measurement over 30 years of data.

We have power in the computing codes that has been brought to every other area. For instance, in developing your cars and planes, all of those use modeling and simulations. This is something where I think the regulations need to be accelerated and changed. I think the legislation helps encourage cooperation among the National Labs, the utilities, NRC and all of us. All of that is absolutely necessary for it to go forward.

Senator Whitehouse. Thank you, Chairman. Again, thank you for your support on these pieces of legislation.

Senator Barrasso. Thank you for your leadership as well. It has been a good, cooperative effort.

Senator Carper, we were talking about what happened with the Halden test reactor. I am going to ask a couple questions

and I know you have a couple as well. I am going to start with Ms. Taylor.

In June, the organization overseeing the Halden test reactor in Norway, announced it would permanently close the reactor. The reactor would have provided critical scientific data necessary for licensing of accident tolerant fuels.

In July, the Electric Power Research Institute participated in a Department of Energy workshop at the Idaho National Lab. The workshop assessed how to fill the gaps in testing capacity that closure of the Halden reactor has left behind.

Could you talk about what the primary gaps in testing capacity were that were identified and what can we do to fill the gaps?

Ms. Taylor. I can address that to some extent.

The Halden test reactor project is more than just a facility. It is a facility that had been a multinational collaboration to fund and plan testing. The reactor had some unique capabilities, two of which were the ability to test the large number of specimens in parallel, so it was very large for a test reactor. It also had some looped capabilities.

Many of the stakeholders have come together. You mentioned the July workshop. Idaho National Lab was the place to kind of convene what the need was. A game plan has been laid out to provide many of those capabilities through additional

capabilities at Idaho.

Senator Barrasso. Are there policies perhaps that the Department of Energy, the Nuclear Regulatory Commission or even Congress should consider to try to fill some of these testing gaps or do you think we will be okay as we are heading?

Ms. Taylor. I cannot really address the policy issues.

Senator Barrasso. Okay.

Mr. Furstenau, what steps is the NRC taking to ensure that the Halden closure does not really slow the progress on licensing the accidental tolerant fuels?

Mr. Furstenau. At the NRC, we also participated in the workshops at the Idaho National Lab. At this point, we think there is no significant impact on the current test plans as we know. I am confident that the Department of Energy, the capabilities at the DOE sites and possibly the universities will really fill that gap in the longer term.

Senator Barrasso. By history, before joining the NRC in your current position, you spent years at the Department of Energy so you have a pretty good understanding of what the capacities are. You feel they are going to be able to fill this?

Mr. Furstenau. Yes, sir.

Senator Barasso. Okay. Thank you.

Senator Carper, do you have additional questions?

Senator Carper. I do have a few. Thanks, Mr. Chairman.

Again, thanks very much for being with us today.

Mr. Williams, ten or so years ago, we were talking about at least 25 brand new light water reactors being built in this Country. Do you remember that? I do.

Mr. Williams. Yes.

Senator Carper. All were expected to come online maybe this year or soon thereafter. In reality, our Nation is only building now, as we know, two new light water reactors. Those two are being built in Georgia by your company.

The effect of the Westinghouse bankruptcy on the nuclear industry is troubling for us and I am sure for you and others. Can you take a moment and tell us how are things going at Vogtle and what are some of the lessons learned that might help the next generation of nuclear power?

Mr. Williams. Senator, I appreciate your question.

Unfortunately, in my role, I focus on our operating fleet of reactors and am not aware of all of the issues associated with the project. We would be happy to respond to your question in writing.

Senator Carper. Does anyone have any insights briefly in this regard? I think it is a pretty good question, better than most of my questions. Does anyone else have any insight you would like to share?

[All respond in the negative.]

Senator Carper. A response for the record from Mr. Williams, but others would be welcomed.

Mr. Furstenau, with respect to NRC planning for accident tolerant fuels, the NRC's draft plan on accident tolerant fuels states, I believe, that the agency will use applicant-provided data or DOE data to determine the safety of a concept and that the agency will not perform its own independent testing.

Would you elaborate on this point? Does the NRC do this in other circumstances? Why does it now make sense to do it for accident tolerant fuels?

Mr. Furstenau. Senator, you are correct about the project, the current plan does not. The assumption is being made that we will not do our own confirmatory testing. However, in the testing programs that are developed by the vendors and industry, we will use data that comes out of that testing program and independently look at that and review it from a confirmatory analysis standpoint.

However, at this point in time, we do not see a need for additional confirmatory testing on these near-term concepts.

Senator Carper. Thank you.

Dr. Back, back to you. As I mentioned in my statement, extreme weather events are expected to be more frequent and more extreme due to climate change. Already nuclear power has proven

to be quite resilient in this Country during these extreme weather events. We are going to be closely watching and be in close step with the NRC to make sure that is the case during Florence.

Would you like to take a moment and discuss how the technologies your company is developing will allow nuclear power to be even more resilient and safe during extreme weather events like Florence and those that follow?

Ms. Back. Yes. Thank you.

As you know, nuclear power performed very well during the Harvey event. There are already advantages in nuclear energy, for instance, of having all the fuel on-site. You do not have pipelines or electricity lines.

For the advanced reactor, there has been a lot of thought along making them more resilient. One, in particular, is the EM² that we envision is a smaller, more compact reactor. Importantly, it is underground so there is protection from things like Florence.

There are passively safe systems and built-in redundancies that are consistent with what are typical NRC regulations so that we make sure it is safe in case of loss of power. For instance, there is an important way that the power conversion unit works with cooling and kicks in with natural convection, if that does not pan out, if there is total loss of electricity.

All of those aspects are thought through and incorporated into the reactor as well as the other efficiencies to be able to run the fuel at higher utilization so that you actually do not need to access the core for 30 years.

Senator Carper. Thank you. I have one more.

This is kind of a wrap-up question. I am going to ask each of you on the panel to respond to this question if you would. Mr. Furstenau, if you would go first.

If you had one piece of parting advice to give to us on the Environment and Public Works Committee with respect to advanced nuclear fuels, what would be that advice?

Mr. Furstenau. I think, in my opinion, it would be we all need to be open and adaptive to enabling new technologies like ATF and advanced reactor concepts that have the potential to make nuclear power even safer.

Senator Carper. Thank you. Ms. Taylor.

Ms. Taylor. I agree. Continuing to encourage innovation in this space which has not always been innovative is yielding new options.

Senator Carper. How should we express that encouragement?

Ms. Taylor. I do not have any suggestions.

Senator Carper. Really? All right.

Mr. Williams.

Mr. Williams. I think the way to encourage it is to

encourage the collaboration between industry and public-private partnerships working together. This is a great example of collaboration between the Department of Energy, the fuel vendors, the utilities and the Electric Power Research Institute to rapidly advance an innovation to deployment.

Senator Carper. Thank you.

Dr. Back.

Ms. Back. My overriding concern is that we need to have data and that means irradiations, something like the advanced test reactor at Idaho National Lab and as you were asking about in Halden.

Those are expensive and need to be done well and be instrumented so that we get the maximum amount of data so we can push forward and make sure we have all the information needed to make sure these materials are safe and perform as they behave.

We need a prioritization and maybe another look at what we can do to make more opportunities available for irradiation testing.

Senator Carper. Let me ask, very briefly, would the other panelists respond to what Dr. Back just said?

Mr. Furstenau. I think her point on needing irradiation test data when you then use modeling and simulation codes, you need to have data to verify those models and codes. I think especially for the concepts like General Atomics referred to,

you do need some of that material that has not been used before. You need that test data to help validate it. It also helps with the licensing process as well as the safety case for the licensees.

Senator Carper. Any other comment in response to what she said?

Ms. Taylor. Just to understand how the fuel behaves in the whole system of the plant, that data is needed to properly model the behavior that you would expect.

Senator Carper. Mr. Williams, anything?

Mr. Williams. No.

Senator Carper. This has been timely and helpful. As the storm bears down, this reminds us all the more that extreme weather has been coming our way for some time and it ain't going to stop. We have to figure out how to respond to it, not to just address the symptoms of the problem but also the root cause of the problems creating all this bad weather for our Country and our world. This could be part of the solution, not the whole solution but part of the solution. We welcome your input today.

Thank you so much.

Senator Barrasso. Thank you, Senator Carper and Senator Whitehouse as well.

Thank all of you for being here to testify. Other members

may want to submit follow-up questions for the record. The hearing record will be open for two weeks.

I want to thank you all for being here, for your time and your testimony.

This hearing is adjourned.

[Whereupon, at 11:15 a.m., the committee was adjourned.]