Testimony of Christina Back, Ph.D.
V.P., Nuclear Technologies and Materials, General Atomics
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Chairman Barrasso and Ranking Member Carper, thank you for the invitation to appear before you today. My name is Christina Back and I am the Vice President of Nuclear Technologies and Materials at General Atomics. General Atomics is a high technology company that has successfully brought solutions to the defense, aeronautics, space, and energy industries. More specifically, my division has a long history of innovation in nuclear energy, starting with the TRIGA reactor in 1956, High Temperature Gas-Cooled Reactors (HTGRs) including the Peach Bottom 1 and Ft. St Vrain power plants, conversion of test reactor fuel from high to low enriched uranium to meet the Global Threat Initiative goals, and more recently to development of the EM^2 advanced reactor, Accident Tolerant Fuel, and novel production of the medical isotope, Molybdenum 99. Today, we remain committed to developing and implementing clean and safe nuclear energy technologies.

A healthy nuclear power industry is essential to the long-term energy security of the United States and it is indirectly essential to our national defense. Nuclear power has been identified as an essential part of our nation's energy mix and it is the largest source of reliable, clean energy available to our nation. Unfortunately, the principal technology employed by the industry, light water reactors, has remained stagnant since the 1970's with the consequence that it is no longer an economically competitive energy source in this century. Our existing nuclear plants have an average age of around 50 years. Nearly all will be shutdown by mid-century and many plants operating in unregulated markets either have been retired early or risk early retirement due to inability to compete with other advanced energy technologies.

At present, there is no U.S.-owned commercial vendor of nuclear power reactors and the supply chain of nuclear-grade materials and components has either gone off-shore or gone out of business. This is in contrast to vigorous nuclear industries in China, Russia, and Korea which have large internal markets for their products and have ambitious plans for export. Unless the U.S. is able to stimulate its near-dormant nuclear industry, the U.S. will be one of their customers in the future.

On the bright side, there is a strong, nascent effort by private industry to innovate new nuclear plants that can be more cost-effective, safer, use less energy resources and produce less waste. But nuclear development is very expensive. No private industry can justify this investment with such a long payback. If the U.S. is to proceed with the development of new advanced nuclear technologies, it will require the support of our government.

The country will benefit by increasing, not decreasing, the fraction of nuclear energy in the mix of energy sources powering our industries and homes. Nuclear provides emission-free, baseload electricity. If we could make nuclear energy cost-competitive it would provide thousands of years of safe, clean electricity for our country. Moreover, being the technology leader in nuclear energy is critically important to minimize foreign dependence and strengthen national security.

Today's nuclear reactors that use existing technology are currently too expensive to be competitive. The U.S. nuclear industry is in decline. To reverse this trend, we believe our country must do what it does best: bring the ingenuity of its people to bear on creating new ways to produce nuclear energy safely, cleanly and at much lower cost.

This legislation is timely, and critically relevant, because there are many advanced reactor concepts that need different materials and require different technologies to advance beyond the light water reactors of today, all of which will need approval as they are developed.

As the Vice President of Nuclear Technologies and Materials at General Atomics, I lead a team of scientists working to solve the challenges facing the nuclear energy industry. Specifically, this work focuses on "advanced reactors" and the advanced materials necessary to make these reactor concepts, and the nuclear industry at large, a cost-competitive reality.

In order to be helpful to the Committee, I would like to define the term "advanced reactors," as it has previously been used interchangeably for a number of reactors. Some classify any non-light water reactor, such as a gas-cooled, sodium-cooled, or molten salt-cooled reactor as "advanced." Others use the term to refer to a new light water reactor, such as a Small Modular Reactor (SMR).

Ultimately, nuclear energy involves splitting an atom and using the heat energy released, to turn a generator to produce electricity. What matters most in our discussion of advanced reactors is that electricity is a commodity, and most consumers care about one thing above all else: cost. The source of the energy, whether it is made from nuclear fuels or from burning coal or gas, or from renewables, is of secondary concern.

To provide that commodity in today's world, an "advanced reactor" must improve over existing reactors in the following 4-core objectives. It must:

- produce significantly cheaper and clean electricity
- be safer
- produce significantly less waste and
- reduce proliferation risk

These four objectives are consistent with the definition of the seven improvements identified for an advanced reactor in the Nuclear Energy Innovation Modernization Act. Essentially, three of the defined improvements: reliability, thermal efficiency and ability to integrate electric and non-electric applications, are connected with the first objective, cost-competitive electricity. Fuel utilization is intertwined with the third objective, less waste. We believe every worthy advanced reactor concept must address these 4-core objectives jointly, it is not sufficient to address one at the expense of the other three, especially cost.

General Atomics is developing a reactor concept, called the Energy Multiplier Module or EM^2, that uses engineered materials and leapfrog technologies, ensuring that the reactor is safer, less waste producing and more proliferation resistant. We kept a laser focus on the commercial application of the reactor and focused on cost-competitiveness, the most challenging of the four core objectives. While the other three objectives are of importance, if we cannot create cost-competitive advanced reactors, the reactor will not make it into the market.

In EM^2, we take advantage of the unprecedented advances in the understanding of materials over the past three decades to engineer and manipulate materials for our nuclear energy application. Our long-term vision for what nuclear innovation can achieve is embodied in EM^2 and our strategy is to approach that end by delivering nearer-term technologies, such as Accident Tolerant Fuel to demonstrate new materials, and Molybdenum 99 development to exercise new technologies. Modernization of the regulatory process, the intent of this legislation, will clearly be needed to realize the benefits of advanced reactors as well as the nearer-term technology innovations.

Now I will go through each of the objectives to illustrate what is possible with new materials and technologies. First is cost. The drive to minimize costs led to the design of a much smaller reactor that could produce much higher power output per reactor volume than today's reactors. It also led to a push to higher efficiency, i.e., 50% more electric power from the same amount of heat. We do this by producing the electricity from higher temperature heat.

Second is safety. For a radical improvement in safety, EM^2 uses **engineered** ceramic materials, as in Accident Tolerant Fuel, that are capable of working in higher radiation and higher temperature environments. The fuel is contained in materials that can survive accident temperatures over 2 times higher and would not be subject to failure like those in Fukushima. While challenges remain, our results have been promising so far. If they hold up, we will revolutionize this industry.

Third is waste. Minimizing waste products is linked to better fuel utilization. For EM^2, this is accomplished by the innovation of long-burn core physics and by higher conversion efficiency. Consequently, EM^2 will use only 20 percent of the fuel and produce only 20 percent of the waste of a current reactor for the same amount of power.

Finally, fourth is non-proliferation. The innovative design of EM^2 keeps the fuel in the reactor for 30 years, without the need to refuel or reposition fuel rods. Less handling of the fuel, and tight security allowed by offsite core fabrication significantly reduces proliferation concerns and lowers operating costs.

As a guiding principle, we believe that to bring advanced nuclear power into the market, the cost of nuclear must be significantly reduced below the existing levels projected for new light water reactors. This reactor, if it performs as designed, would produce power at perhaps 40% lower cost than today's existing nuclear reactors, and with a capital investment per EM^2 unit in the $1.5 billion range. It would be produced in a factory, reducing proliferation concerns and potentially reducing licensing costs, and shipped to the site and installed within 4 years, again keeping costs down.

As for any new reactor design, this one will require extensive interactions with the NRC. In particular, this radically new material requires intensive development and testing. We think involving the NRC early in this work is imperative. Ideally, interactions would occur early enough to inform the design from the beginning and produce a safer reactor design. Then, when we applied for licensing based on what the market called for, a few years from now, this early effort would pay off many times over.

Radically new concepts that employ new technology require upfront investments involving some risk. Some of these investments may not pay off, and even those that are successful could require at least 10 years to produce any revenue. While General Atomics has already invested $40 million in the EM^2 concept, these commercial realities make it very difficult to justify early costs to engage the NRC.

If this Committee's objective is to stimulate the development of new advanced reactor concepts, we would suggest that it is in this early phase of development that it would be relatively inexpensive to involve the NRC for early consultations with potentially very high impact. Every advanced reactor concept that involves significant long lead development would benefit enormously from being able to work with the NRC at an early stage.

We suggest the Committee consider authorizing the appropriation of $5 million at first, growing to possibly $15 million over 5 years, to provide NRC services to developers of advanced reactor concepts. To trigger funding, a relatively low cost share of perhaps 3%, could be required. In addition, the NRC could engage outside advice from the DOE, universities, and other experts, to ensure the individual reactor concepts were viable.

While outside of this Committee's jurisdiction, we also believe that a public-private partnership is necessary to achieve the goal of advanced reactors. The advantages of this approach are noted in the recent Secretary of Energy Advisory Board Task Force Report on the Future of Nuclear Power. Although such an effort would require a significant investment on the part of the federal government, it would yield benefits including: a new generation of nuclear scientists, domestically held intellectual property, and a cost-effective means for producing pollution-free baseload power that increases safety, reduces waste, and is proliferation-resistant.

Thank you for your interest in this subject, and this opportunity for me to appear before you. The excitement of discovery in science and the satisfaction of making a safe and more efficient reactor keeps me engaged and eager to continue to push the boundaries of science and harness the energy in the nucleus. The NRC is an important and necessary agent in ensuring nuclear power remains safe. Therefore, it plays a critical role in nuclear power innovation. I would be pleased to respond to any questions you may have.