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United States Senate
Committee on Environment and Public Works

Hearing on Advanced Nuclear Technology: Protecting U.S. Leadership and Expanding Opportunities for Licensing New Nuclear Energy Technologies

June 4, 2019

Thank you Chairman Braun, Ranking Member Whitehouse and members of the subcommittee for the opportunity to testify. My name is Chris Levesque, and I am the Chief Executive Officer of TerraPower, an advanced nuclear technology company based in Bellevue, Washington. In 2006, our company's founders - Bill Gates and Nathan Myhrvold – began looking for a technological solution to the dual challenges of the growing global demand for energy and the rising threat of climate change. The answer, they discovered, is advanced nuclear technology. TerraPower has spent more than a decade developing technology that can produce reliable, low-cost, carbon free power to meet those challenges.

The mission of advanced nuclear energy companies like TerraPower is to improve nuclear energy technology on a number of fronts, using the capabilities offered by 21st century technologies and digital modeling previously unavailable. They move well beyond our country's 20th century fleet of light water reactors, including safety improvements, reductions in the risk of weapons proliferation, minimization of waste production, more efficient use of uranium supplies and, eventually, lower costs. TerraPower's goal is to provide a commercial product that provides reliable, zero-carbon, cost-effective electric and thermal energy solutions that can be deployed in the United States and abroad.

Why Invest in Advanced Nuclear Technology?

Nuclear energy solves a broad array of energy and fuel problems. First, like wind and solar, nuclear power is carbon free and can be a key tool in efforts to reduce emissions and pollution. Secondly, like coal and natural gas, nuclear power can provide power 24 hours a day and 7 days a week. But unlike coal and natural gas, nuclear neither emits carbon dioxide or other air pollutants, nor does it require continual delivery of commodities to produce power. The result is always-available, carbon free power that does not require a natural gas pipeline or a coal train to operate. No other form of power has all of these attributes.

We are confident advanced nuclear will meet a number of global market needs. Few potential export markets in the world are as blessed with the kinds of natural resources we enjoy in the United States. Many of these countries rely on international pipelines, rail and ship infrastructure, and relationships with other countries to meet their domestic energy needs. Energy dependence is a serious economic and national security issue for many countries in Europe and Asia. As such, sources of power that require low volume, highly efficient fuel – like advanced nuclear – have great commercial and strategic appeal.

In addition to the economic and national security aspects of nuclear power, every potential export market for American nuclear technology has signed onto the Paris Climate Agreement. The United Nations' Intergovernmental Panel on Climate Change (IPCC) provides a number of pathways to keep global emissions below 1.5 degrees Celsius. None of those pathways allow for a reduction of the share of global power provided by nuclear, and the high economic growth scenario calls for global nuclear power demand to increase by five times current levels.[1] But

[1] https://www.iph/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf

new reactors take time to build and scale, which is why it's imperative to marshal resources and expediently license a portfolio of new reactor technologies.

Given the demand for power generation with these attributes and the global strategic implications, it should not be surprising that other countries are working to develop advanced nuclear technology. Countries like China and Russia are actively supporting the development of advanced reactors with significant direct investment by government into state-supported companies. This direct government support helps these countries establish a valuable export product, but the sale of a reactor also brings important national security benefits for those governments. Some of these state-supported companies sell their reactors with a multi-decade contract to provide fuel, operations and maintenance services, and waste services. This creates a multi-decade strategic partnership between the country selling nuclear reactors, and the country purchasing that technology. Russia, for example, is currently offering these "Build, Own, Operate" contracts in Europe and the Middle East.[2]

Civil nuclear power was invented in the United States, and every advanced nuclear technology under development across the globe was invented in the United States, with support from U.S. taxpayers. Our nation should benefit from that investment, both in terms of the technology we can build to meet our domestic clean power needs, and in terms of the economic and national security opportunity for American companies to sell their products around the world. To achieve these benefits, however, our country needs to make significant investments and a sustained commitment to advance a portfolio of the most promising reactors our country has invented.

What is advanced nuclear, or "Generation IV?"

Generation IV nuclear solutions essentially improve all the critical attributes—efficiency, economics, waste, and safety—compared to the current light water fleet. They allow for greater overall plant efficiency by operating at higher temperatures. This yields carbon-free electricity generation, enables integrated energy systems and larger scale deployment of renewable energy, and provides more heat for industrial applications. A simplified nuclear fuel cycle improves fuel resources and significantly reduces costs and proliferation concerns of waste transportation, storage and disposal.

The costs of nuclear energy include plant construction, operations, fuel and waste treatment. Compared to last century's technology, advanced nuclear designers are developing reactors that will improve the affordability of nuclear energy. Advanced reactors operate at higher temperatures, yielding more electricity and lower costs per kilowatt-hour for the same plant size. Additionally, non-water reactor designs require less maintenance and fuel. Estimated operating costs are about 20 percent less than the current fleet.

[2] https://www.belfercenter.org/publication/russian-nuclear-energy-proposal-offer-you-cant-refuse

One type of advanced nuclear reactor design allows for smaller fuel purchases at much less frequent intervals. The historic refueling cycle for today's water-cooled reactors is every 18 to 24 months. Advancements, coupled with innovative fuel-coolant combinations, reduce that cycle to once every ten years for certain next-generation technologies. Furthermore, they have the potential to make up to 30 times more energy out of each ton of mined uranium.

Advanced nuclear energy developers are pursuing designs that need less mining, enrichment services and temporary spent fuel storage. Reactors will avoid the costs of building and operating reprocessing plants, as well as the related waste clean-up costs. Some of these new reactors will generate about one-fifth of the waste that today's reactors create.

High energy density uranium produces low volumes of waste compared to other energy sources. Today fission product waste is safely contained at plant sites until they are permanently disposed. These facilities remain under safe control and federal regulation, unlike waste byproducts from other sources of electricity generation. Some advanced reactor technologies generate much smaller amounts of waste enabling new and more efficient approaches to waste disposal. Additionally, many fast reactors can use depleted uranium, typically discarded as a byproduct of enrichment.

Nuclear power also has consistently proven to be the safest way to make electricity. A 2013 paper[3] produced by NASA's Goddard Institute authored by Pushker Kharecha and James Hansen in the journal *Environmental Science and Technology* also supports nuclear power's claim to mitigate health detriments of fossil fuels with the striking figure of 1.8 million as the number of lives saved by replacing fossil fuel sources with nuclear.[4] They estimated the savings of up to 7 million lives in the next four decades, along with substantial reductions in carbon emissions, were nuclear power to replace fossil fuel usage on a large scale. Advanced reactors offer next-generation safety benefits that permit new applications and expand the potential to use nuclear energy for more than electricity production. This new technology will not require active safety systems, eliminating the need for diesel engines, multiple back-up systems and human intervention under emergency scenarios. If you were to put these reactors through the Fukushima test, there would be no accident. A fast reactor would have shut itself down independently, indefinitely.

Some systems avoid high pressure and rely on the natural laws of physics to maintain the safety of the plant without needing operator intervention or auxiliary power, using air and the properties of natural convection, rather than water, as the ultimate heat sink. Safety features in the selection of fuels and coolants provide for enhanced versatility and permit more flexible siting, with a much more compact site and a smaller emergency planning zone within the site boundary.

There also is a long-held concern that civilian nuclear technology could be inappropriately applied for military purposes. Advanced fast reactors substantially lower the risk that key bomb materials – enriched uranium and plutonium – could be diverted to make weapons. This is

[3] https://pubs.giss.nasa.gov/docs/2013/2013_Kharecha_kh05000e.pdf

[4] https://blogs.scientificamerican.com/the-curious-wavefunction/nuclear-power-may-have-saved-1-8-million-lives-otherwise-lost-to-fossil-fuels-may-save-up-to-7-million-more/

accomplished by consuming the plutonium produced in the reactor as fuel, eliminating the need for reprocessing or using depleted, instead of enriched, uranium as a fuel. This makes the reactor designs we are working on both safe and exportable.

U.S. nuclear technologies and research and development capabilities are envied around the world, and the U.S. enjoys close political and commercial relationships with many countries forged over decades through the construction of U.S.-origin nuclear plants. Exports of U.S. nuclear technology allow the U.S. to set global standards for nuclear security, safety and nonproliferation. The Nuclear Energy Institute points out that reactor exports allow the United States to form 100-year strategic relationships around the world that span the construction, operation and decommissioning of a plant. U.S. nuclear innovators, including TerraPower, have advanced their technology readiness levels sufficiently for early demonstration and offer substantial advances in economics, safety and proliferation resistance. Now is the time to build on the momentum of these innovators.

Meeting Energy Demand in the United States

As noted, advanced nuclear technologies are well positioned to meet market needs throughout the world. But we also see a robust domestic market for our technology. In 2017, nuclear energy generated 20 percent of U.S. electricity and 56 percent of our emissions-free generation, more than all other sources combined. A single nuclear plant produces as much emissions-free electricity as it took to power all electric vehicles in the United States in 2017. Nuclear energy is the only carbon-free electricity source that can provide large, baseload amounts of electricity around the clock. An average nuclear energy facility's life-cycle carbon footprint is comparable to wind, and lower than solar and hydro power plants.

With capacity factors exceeding 90 percent and built to withstand extreme weather – which Is now tested annually as was recently evidenced by recent fires, tornados, hurricanes, and frigid temperatures – nuclear plants generate electricity around the clock when other sources become unavailable. While we've seen a wave of plant closures and as our domestic fleet reaches the end of its licensed life, advanced nuclear designers are developing reactors that can replace reactors as they retire, meet price goals, and lower the overall cost of nuclear energy.

Additionally, as state and federal governments look for ways to expand fuel diversity and reduce pollution and emissions, there will be a market in the United States for advanced nuclear technology. That market will be met either by domestic or foreign reactor companies. In addition to the economic opportunities in the domestic market, for national security reasons, we want our domestic nuclear power needs met by American companies and domestic technology.

The Role of the Federal Government

Unlike many of our foreign competitors, America's advanced nuclear industry is made up of private companies backed by private investors who partner with our national laboratories, research universities, and agencies, like the U.S. Department of Energy, to develop domestic advanced nuclear technology.

As this committee knows well, nuclear energy is an industry that is heavily regulated, posing significant uncertainly to reactor developers, is very capital intensive and requires access to sophisticated facilities, test reactors, and equipment. These challenges pose significant risks to recouping a return on investment and thus inhibit investment, particularly when scaling-up new nuclear technologies. The U.S. government has a key role to play in reducing these risks, providing direct support, and removing barriers to research, development and deployment to ensure the United States remains a leader in nuclear energy technologies.

TerraPower appreciates the work of both this committee and the Nuclear Regulatory Commission (NRC) to prepare for the licensing of advanced nuclear technology. The enactment of the Nuclear Energy Innovation and Modernization Act (NEIMA) will provide significant help, and we are grateful for your leadership and work on that legislation. We look forward to continuing to work with the NRC on implementing NEIMA and licensing advanced reactors.

Beyond the NRC, advanced reactors will need the support of the DOE and our national lab complex. Our national labs are a national asset and are vital to industry to develop, test, and deploy new technologies. TerraPower has established strong technical relationships and jointly beneficial partnerships with the labs. Public-private partnerships with the national laboratories have led to rapid and significant progress on the research and development of advanced nuclear technologies. But the primary goal needs to be the commercialization of advanced reactor technologies that can meet the demand for reliable, clean, scalable, and affordable power. The next, and most important, challenge will be developing a system to demonstrate those technologies to meet both domestic and global market demands in a time frame that matters. We are encouraged by discussions and activities that are happening in the U.S. federal government to support the demonstration of advanced nuclear technologies.

On this front, TerraPower believes one of the most important tools in that discussion is S. 903, the recently introduced Nuclear Energy Leadership Act (NELA). This legislation presents a vision and execution strategy with specific targets and milestones to advance the nuclear industry, including, advanced reactor research goals, a fast neutron test facility along with high-assay, low-enriched uranium for research and the demonstration of several advanced nuclear reactors. We appreciate that a number of members of this committee have joined as co-sponsors of this important bill and we hope Congress will move to pass NELA expeditiously. However, even without NELA, the federal government can move to develop and fund more coordinated and expedient demonstration activities for those companies ready to graduate from the R&D phase.

I want to stress that the need for demonstration is critical—for TerraPower specifically but also for the advanced nuclear community generally. No company can commercialize advanced nuclear technology and bring down costs until it is demonstrated. In the near-term, the only way to kickstart the advanced nuclear industry is to demonstrate a portfolio of reactors. Demonstrating multiple reactors will not only validate new designs, but also will enable companies to establish supply chains, bring down costs and begin to scale—all of which will

bring economic, employment, and environmental benefits. There are several analogies that give us confidence that we can accomplish this in partnership with the U.S. government. Recall solar energy's start was not affordable; solar energy became affordable through cost curves driven by government funded RD&D, deployment policies like the Loan Programs Office, and robust growth in commercial markets that led to new learnings, innovations, and considerable cost reductions through manufacturing improvements. We need a similarly ambitious effort to move advanced nuclear forward.

Conclusion

The country that owns the advanced nuclear transition will be a leader in the global nuclear market and fulfill the international goals of deploying clean energy, supporting energy security, lifting millions out of energy poverty, and driving economic growth. The nuclear industry is critical to providing the safe and clean baseload power the world will require over the coming century.

The United States is sitting on a massive opportunity to build out and own the advanced nuclear industry, and the benefits are clear. The U.S. has a great history of innovation. Our country led the world in developing civilian nuclear power since the 1950s and has decades of R&D expertise on a wide range of reactor concepts. The U.S. deserves to reap the economic and national security benefits created by that innovation and expertise. With the right public private partnership and investment, I know we can.

Additional Information

American Energy Innovation Council Report – Energy Innovation: Fueling America's Economic Engine[5]

Third Way Report on Advanced Nuclear Industry [6]

TerraPower Co-founder and Vice Chairman Nathan Myhrvold Op-Ed on Nuclear Energy Innovation[7]

[5] http://americanenergyinnovation.org/wp-content/uploads/2018/11/Energy-Innovation-Fueling-Americas-Economic-Engine.pdf
[6] https://www.thirdway.org/graphic/keeping-up-with-the-advanced-nuclear-industry
[7] https://www.intellectualventures.com/buzz/insights/why-we-need-innovative-nuclear-energy