Statement of

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"The Future of Nuclear Power"

Before the

Congress of the United States
United States Senate
Committee on Appropriations
Subcommittee on Energy and Water Development
SD-138 Dirksen Senate Office Building

November 16, 2016

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Introduction

Chairman Alexander, Ranking Member Feinstein, and members of the Subcommittee, thank you for providing the Natural Resources Defense Council, Inc. (NRDC) this opportunity to present our views on "The Future of Nuclear Power."

NRDC is a national, non-profit organization of scientists, lawyers, and environmental specialists, dedicated to protecting public health and the environment. Founded in 1970, NRDC serves more than two million members, supporters and environmental activists with offices in New York, Washington, DC, Los Angeles, San Francisco, Chicago, Bozeman, Montana, and Beijing. NRDC has been engaged with the environmental issues surrounding nuclear energy and nuclear weapons since our founding, and NRDC maintains a Nuclear Program staffed by a nuclear physicist, a nuclear engineer, a radiation health physicist and an attorney.

This testimony focuses on four topics: (1) the future of nuclear power, including NRDC recommendations to the Subcommittee regarding research, development and demonstration (RD&D) of advanced nuclear reactors; 2) deployment of small modular reactors (SMRs); 3) development and licensing of advanced nuclear reactors; and 4) nuclear energy RD&D by the U.S. Department of Energy (DOE).

The Future of Nuclear Power

Facing significant challenges, the future of nuclear power in the United States is uncertain. Today 99 reactors produce 19.5 percent of U.S. electricity; most of these reactors will reach the end of their current licenses and may close by mid-century, and approximately fifteen percent of these reactors are at risk of near-term closure due to market competition, including the possible need to replace expensive major components. Only four reactors are currently under construction in the United States. In addition to the economic challenges for nuclear power, difficulties for nuclear power arise from safety, security, proliferation and nuclear waste. The position of nuclear power as a low-carbon energy resource is being superseded by advances in energy efficiency and renewable energy technologies. A primary role of the federal government in energy policy is to foster energy technologies and energy systems with public benefit – prioritizing values of energy sustainability and stability of supply at low cost and without public health and environmental harms. NRDC is skeptical that nuclear power can deliver these energy values in the future.

Nevertheless, the federal government will continue to play primary roles in nuclear energy policy: in oversight of safety and security at operating nuclear reactors; in preventing the proliferation of nuclear weapons; and in disposing of spent nuclear fuel in one or more deep geologic repositories. Other important roles of the federal government include support of programs in nuclear engineering and science and in health physics at our universities and national laboratories.

The future of nuclear power could be impacted by new nuclear technologies. Today all reactors in the United States delivering electricity to the grid use low-enriched uranium as fuel with light water (i.e., water containing the natural proportions of hydrogen isotopes) serving as the coolant and neutron moderator. These U.S. light water reactors (LWRs) are of two basic designs: the Pressurized Water Reactor (PWR) and the Boiling Water Reactor (BWR), with the latter making up about one-third of operating reactors. Of the new and proposed nuclear power technologies – all as yet untested via operating U.S. prototypes – the AP1000 and the NuScale SMR are PWRs, and similarly use low enriched uranium as fuel and light water as the coolant and moderator. But there are also a host of other nuclear technology concepts being advocated for future federal research and development support that are varied in terms of potential technological attributes.

Termed "advanced reactors," these include, but are not limited to, the sodium-cooled fast reactor (SFR), the lead-cooled fast reactor (LFR), the gas-cooled fast reactor (GFR), a variety of molten salt reactor designs (MSRs), the high-temperature gas reactor (HTGR) and very high temperature gas reactor (VHTGR). These can be designed as large reactors or SMRs. DOE when referring to "advanced reactors" excludes LWRs. This is misleading because some of the non-LWR concepts predate LWRs and there are new LWR designs, e.g., some SMRs, that are more advanced that the current fleet of deployed LWRs. NRDC's testimony will address selected advanced reactor concepts individually, and NRDC respectfully offers five recommendations for the Subcommittee in consideration of advanced nuclear energy research and development:

A. Prioritize solving the nuclear waste problem over the demonstration of new nuclear technology;
B. Wait for the construction of domestic AP1000s and a prototype SMR, and assess lessons learned from their safety, reliability and potential economic competitiveness before entertaining federal cost sharing investments to license and construct non-LWR advanced nuclear reactor demonstration plants;
C. Consistently apply a nuclear weapons proliferation test to advanced nuclear designs;
D. Consider severe accident consequences and the full impacts of the nuclear fuel cycle associated with advanced nuclear reactors; and
E. Require greater clarity on likely economic competitiveness for advanced nuclear designs earlier in the research and development cycle.

These five recommendations address the varied impacts of nuclear power and the legacies and lessons from past nuclear operations in the United States.

A. Prioritize solving the nuclear waste problem over the demonstration of new nuclear technology

Nuclear power has resulted in the production of approximately 72,000 tons of spent nuclear fuel which is currently stored at operating nuclear power plants or decommissioning reactor sites at over 100 sites across the United States, and continued operation of existing U.S. nuclear reactors will result in producing another 70,000 tons for a total of over 140,000 tons by mid-century.[1] Due to high levels of radioactivity, this spent nuclear fuel must be isolated from

[1] Moving Forward with Consent-Based Siting for Nuclear Waste Facilities: Recommendations of the

people and the environment for millennia, and thus is an intergenerational problem. NRDC recommends to the Subcommittee that the federal government should give higher priority to demonstrating the geologic disposal of spent fuel and high level nuclear waste over demonstrating advanced nuclear reactors.

B. Wait for the construction of domestic AP1000s and a prototype SMR, and assess lessons learned from their safety, reliability and potential economic competitiveness before entertaining federal cost sharing investments to license and construct non-LWR advanced nuclear reactor demonstration plants

The four nuclear power plants now under construction in the United States in Georgia and South Carolina are all AP1000s. The engineering goals of the AP1000 design are improved safety, increased operating efficiencies and smaller physical footprint than currently operating reactors. The four AP1000 construction projects are over budget and behind schedule, with the target of early next decade for first connection to the electric grid. Operator experience, capacity factors and importantly the capital cost and operation and maintenance costs of the AP1000 will remain uncertain until the completion of these projects. Given that the AP1000 represents the bulk of today's federal, state and ratepayer investment in new nuclear power technology, the AP1000 should be carefully assessed before further significant federal investment in advanced nuclear reactors, to determine whether the AP1000 is likely to play a role in the future of nuclear power in the United States.

Not as far along as the AP1000 is the SMR nuclear reactor concept. The federal government is currently supporting work to prepare one SMR design for license application at the U.S. Nuclear Regulatory Commission (NRC) – the NuScale SMR – and may support construction of a first NuScale SMR plant at Idaho National Laboratory (INL). If a first comprehensive SMR license application is submitted to the NRC in 2016, the NRC has outlined a license application review of 39 months, or possibly through 2020. But there are many unknowns for SMR licensing that impact cost and operations, for example the size of the SMR

BPC Nuclear Waste Council, Bipartisan Policy Center, September 2016, http://bipartisanpolicy.org/library/consent-based-siting-nuclear-waste/.

Evacuation Planning Zone, and requirements on SMR plant staffing and security. Given that the SMR represents a substantial current U.S. government investment in new approach to commercial nuclear power, the SMR technology should be further assessed regarding its economic viability before further federal investment in non-LWR advanced nuclear reactors, as the NuScale SMR may or may not be built.

C. Consistently apply a nuclear weapons proliferation test to advanced nuclear designs

Among energy technology choices for the United States, nuclear power is unique in that there are substantial overlaps between civilian energy technology and military applications of this technology to nuclear weapons. The risk of nuclear weapons proliferation can be managed but not eliminated. Preventing the proliferation of nuclear weapons remains a cornerstone of U.S. national security policy and is of utmost importance in considering the future of nuclear power.

Proliferation risk depends on the design of a nuclear reactor, safeguards on its operation, and the reactor's associated nuclear fuel cycle. At the front end of the nuclear fuel cycle, the capacity to enrich uranium for use as fuel in LWRs has the inherent potential to produce highly-enriched uranium for nuclear weapons. At the back end of the nuclear fuel cycle, reprocessing of spent nuclear fuel confers the technical potential to produce plutonium for nuclear weapons.

If spent nuclear fuel is not reprocessed, the fuel cycle is defined as a "once-through" or "open" nuclear fuel cycle, and if spent fuel is reprocessed (with or without reuse as reactor fuel), the nuclear fuel cycle is defined as "closed." As a general matter, the open nuclear fuel cycle represents a significantly reduced proliferation risk compared to a closed nuclear fuel cycle.

Advanced nuclear designs should reduce or at least not increase proliferation risks compared with current LWR technology. Reactor concepts that contemplate reprocessing spent fuel should not be pursued during the foreseeable future.

D. Consider severe accident consequences and the full impacts of the nuclear fuel cycle associated with advanced nuclear reactors

Full impacts of plant operations and the nuclear fuel cycle include: uranium mining, enrichment and fuel fabrication; normal nuclear plant operations and accident scenarios; decommissioning of closed nuclear reactors and interim storage and final disposition of spent fuel. There are substantial aspects of the nuclear fuel cycle for current LWRs that must still be resolved. Three prominent examples are the currently inadequate U.S. regulatory frameworks for In-Situ Leach uranium mining, nuclear reactor decommissioning, and interim storage and final disposition of spent nuclear fuel.

The full life cycle impacts of operations and the nuclear fuel cycle need to be considered for advanced nuclear reactor designs early in the research and development cycle.

E. Require clarity on economic competitiveness for advanced nuclear designs early in the research and development cycle.

Before significant federal investing in research and development of advanced nuclear technologies, there should be greater clarity on economic competitiveness. The economic competitiveness of advanced nuclear will incorporate issues identified above: safety, operations and maintenance, decommissioning and waste.

As seen in recent nuclear reactor closures, the current market competitiveness of LWR technology is fragile. The price of electricity from AP1000 and SMR reactors will likely be at least as expensive or more expensive than from currently operating reactors. While the AP1000 has the relative economic benefit of larger scale, the business model for the SMR seeks to make up some of the competitive difference with the AP1000 through efficiencies in construction, operation and maintenance, and decommissioning. The price of electricity from advanced nuclear will likely be more expensive than from AP1000 or NuScale SMRs due to additional complexities of design and operations for non-light water technologies.

The federal government should not invest research and development funds into non-LWR advanced nuclear projects without early clarity on economic competitiveness, as ultimately this will be one important factor in whether the technology flourishes or becomes yet another failed federal effort to force nuclear energy onto the commercial marketplace.

Deployment of Commercial Small Modular Reactors

Over the past decade the status of SMRs has developed from initial interest and exploratory work, through preliminary SMR design programs by several consortia and businesses, and now to an imminent SMR design certification application to the NRC by NuScale Power and Utah Associated Municipal Power Systems (UAMPS) – the first such SMR licensing application in the United States. NuScale and UAMPS then plan to apply to the NRC for a combined construction and operation license in late 2017 or early 2018.[2] In February 2016 DOE issued a Site Use Permit to the UAMPS Carbon Free Power Project granting it access to the Idaho National Lab site for the purposes of identifying potential locations for the NuScale Power Plant.[3] The license application to the NRC will likely reference an SMR design containing up to 12 reactor modules at the single UAMPS nuclear plant. DOE has played a substantial role in SMR research and development.

The NRC staff has developed a 39-month "optimum baseline schedule" for evaluating the SMR license,[4] but SMR licensing may prove challenging. particularly with respect to the size of the Emergency Planning Zone (EPZ).[5] Planning for nuclear accidents within the EPZ is one of the government's most important responsibilities in nuclear energy policy with the goal of

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[2] NuScale Power, LLC and Utah Associated Municipal Power Systems Combined Response to NRC Regulatory Issue Summary 2015-07, June 17, 2015, http://pbadupws.nrc.gov/docs/ML1517/ML15170A296.pdf.
[3] U.S. Department of Energy Use Permit No. DE-NE700065, February 17, 2016, http://www.id.energy.gov/insideNEID/PDF/DOE_UAMPS%20Use%20Permit%20DE-N700065.pdf.
[4] Status of the Office of New Reactors Readiness to Review Small Modular Reactor Applications, U.S. Nuclear Regulatory Commission, August 28, 2014, http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2014/2014-0095scy.pdf.
[5] Ramana, M. V., Laura Berzak Hopkins, and Alexander Glaser. "Licensing small modular reactors." *Energy* 61 (2013): 555-564.

averting and minimizing radiation doses to people at risk from an accident. For an SMR, a smaller EPZ reduces cost and opens potential new markets near population centers, but with a corresponding loss of safety in defense in depth. Other outstanding issue for SMR licensing that also implicate SMR economics are requirements for site personnel and security, safeguards against cyber threats for digital instrumentation and controls, and decommissioning.

The 50 MWe output of a single NuScale SMR module should be compared with the approximately 100 GWe of current U.S. nuclear capacity. Replacing current U.S. nuclear capacity with NuScale SMRs would require approximately 2,000 NuScale reactors. The business model for the SMR includes favorable assumptions about cost savings from assembly-line manufacturing and industrial learning; however NRDC cautions members of the Subcommittee to visualize the vast scale of SMR adoption that would be required to have any impact on future U.S. nuclear energy use. While the regulatory hurdles and future operational uncertainties of the NuScale SMR project are substantial, the NuScale SMR design is better understood than advanced non-light water nuclear reactor designs.

Development and Licensing of Advanced Nuclear Reactors

For decades, nuclear scientists and engineers have sought to develop reactor designs that involve one or more of the following goals: reduce the amount of nuclear waste generated, involve the production or handling of weapons-useable nuclear material, and lower the likelihood or the consequence of severe accidents. The current leading concepts for advanced non-LWRs also pursue some of these goals. While there are many non-LWR advanced nuclear technologies in early stages of development (many of them based on ideas from early in nuclear power programs), no advanced nuclear design has demonstrated any of these goals in a working prototype. These benefits of advanced nuclear are still theoretical at present. More importantly there is no evidence that any would be economically competitive with renewable energy technologies or even with the AP1000 or the NuScale SMR.

From a practical standpoint, advanced reactors are just different reactor types that must compete economically with energy resources that are currently available, including renewable energy resources. Past experiences with non-LWRs has been largely unsuccessful. Some non-LWR advanced nuclear reactor designs use fast neutrons to sustain criticality (in comparison to light water reactors that use slow or thermal neutrons), and some non-LWR designs breed and burn additional fissile material during operations. Dozens of fast breeder reactors were built and have operated for varied lengths of time since the 1950s.[6] Because of the high costs and reliability and safety issues for fast breeders, no commercial breeder reactors have been deployed in a competitive energy market setting.

There is a consensus within the scientific community that advanced nuclear will remain a costlier nuclear technology option than LWRs until a speculative, future period of uranium scarcity not anticipated before the end of this century. For example, a 2011 study by the Massachusetts Institute of Technology “The Future of the Nuclear Fuel Cycle” concluded: “There is no shortage of uranium resources that might constrain future commitments to build new nuclear plants for much of this century at least. … For the next several decades, a once through fuel cycle using light water reactors (LWRs) is the preferred economic option for the U.S. and is likely to be the dominant feature of the nuclear energy system in the U.S. and elsewhere for much of this century. Improvements in light-water reactor designs to increase the efficiency of fuel resource utilization and reduce the cost of future reactor plants should be a principal research and development focus.”[7]

Some proponents of advanced nuclear reactor designs argue that these reactors coupled with a closed nuclear fuel cycle will address the nuclear waste problem. But, in reality, advanced nuclear will increase the U.S. nuclear waste burden, and the root of the nuclear waste problem is the lack of geologic disposal sites for the waste from any kind of nuclear power reactor.

[6] Cochran, Thomas B., et al. "Fast breeder reactor programs: history and status." International Panel on Fissile Materials (2010).
[7] Kazimi, Mujid, et al. "The future of the nuclear fuel cycle." Massachusetts Institute of Technology, Cambridge, MA (2011).

Advanced reactors concepts differ substantially in design and operation, including nuclear fuel cycle aspects, from the currently licensed and operating U.S. light water reactors. There are many advanced nuclear reactor design concepts. The United States is part of the Generation IV International Forum (GIF)[8], a collaboration among 14 countries "on the development of advanced next generation nuclear energy systems." Members of GIF evaluated 130 advanced nuclear reactor concepts and selected six technologies for further research and development focus: gas-cooled fast reactor; lead-cooled fast reactor; molten salt reactor; super-critical water-cooled reactor; sodium-cooled fast reactor; and very high temperature reactor. But even with respect to these six categories of advanced nuclear reactor concepts, the designs are varied and utilize thermal or fast neutrons, incorporate closed and open fuel cycles, and envision reactor sizes from very small to very large. The GIF defines technology goals for advanced nuclear as: "Sustainability, economics, safety and reliability, and proliferation resistance and physical protection." Within the GIF, the United States has expressed commitment to two of these advanced nuclear designs: the sodium-cooled fast reactor (with a closed nuclear fuel cycle) and the very high temperature reactor (with an open or closed fuel cycle).

In January of this year DOE announced[9] a selection of two companies for a multi-year cost share of up to $80 million in total to further develop advanced nuclear designs:

- X-energy[10] – partnering with BWX Technology, Oregon State University, Teledyne-Brown Engineering, SGL Group, Idaho National Laboratory, and Oak Ridge National Laboratory to solve design and fuel development challenges of the Xe-100 Pebble Bed Advanced Reactor; and
- Southern Company Services[11] – partnering with TerraPower, Electric Power Research Institute, Vanderbilt University, and Oak Ridge National Laboratory to perform integrated effects tests and materials suitability studies to support development of the Molten Chloride Fast Reactor.

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[8] GEN IV International Forum: https://www.gen-4.org/gif/jcms/c_9260/public.
[9] http://www.energy.gov/articles/energy-department-announces-new-investments-advanced-nuclear-power-reactors-help-meet
[10] http://www.x-energy.com/
[11] http://www.southerncompany.com/news/2016-01-15-so-nuclear-technology.cshtml

The X-energy advanced reactor concept is for a high temperature gas-cooled reactor (HTGR) design utilizing the thermal neutron spectrum and consisting of a "four-pack" of 50MWe units together generating 200MWe. HTGRs can operate with an open or closed fuel cycle.[12] A review[13] of the history of this technology has highlighted severe hurdles this technology must overcome: "HTGRs are prone to a wide variety of small failures, including graphite dust accumulation, ingress of water or oil, and fuel failures. Some of these could be the trigger for larger failures or accidents, with more severe consequences." The economic outlook for the Xe-100 advanced nuclear design would also face challenges in high capital cost for power plant construction, lower capacity factors and a reduced operating lifetime. The DOE Next Generation Nuclear Plant (NGNP) program tried to commercialize the HTGR[14] but failed because no industrial entity was willing to cost-share with the U.S. government on an annual 50-50 cost sharing basis. In other words, the DOE has already tried to develop this option once without success.

The Southern Company-led advanced reactor concept is for a molten salt design utilizing the fast neutron spectrum. The molten salt reactor concept was developed at Oak Ridge National Laboratory in the 1960s, but it has not been developed commercially. The Molten Chloride Fast Reactor has many technical challenges in materials and construction. The program managed by Southern is focused on benchmarking calculations with data from testing in a non-nuclear environment, for example: material corrosion rates, synthesis methods for fuel salts, salt properties, thermal hydraulics, heat capacities, and viscosities. Fundamental questions remain before costing and construction estimates can provide a sense of the possibility for licensing and commercialization of the Molten Chloride Fast Reactor. NRDC recommends scrutiny of this program with respect to several key questions: Have the corrosion problems for molten salt been sufficiently addressed with respect to the requirements of a commercial plant? Will the associated nuclear fuel cycle separate fissile material from the bulk of the salt? How will nuclear weapons materials be accounted for in proliferation safeguards?

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[12] Piet, Steven J., Samuel E. Bays, and Nick R. Soelberg. "HTGR Technology Family Assessment for a Range of Fuel Cycle Missions." Idaho National Laboratory: Idaho Falls, ID (2010).
[13] Ramana, M. V. "The checkered operational history of high-temperature gas-cooled reactors." *Bulletin of the Atomic Scientists* 72.3 (2016): 171-179.
[14] Kadak, Andrew C. "The Status of the US High-Temperature Gas Reactors." *Engineering* 2.1 (2016): 119-123.

The practical nuclear engineering and economic hurdles inherent in these technologies are such that NRDC questions whether advanced nuclear will ever be commercialized and therefore even shoulder a small fraction of energy demand in fast evolving energy markets that address the pressing needs of mitigating climate change. Furthermore, as an environmental advocacy organization, NRDC has concerns that advanced nuclear may serve as a distraction to the rapid, continued scale-up of existing, economically viable and proven solutions to the threat of climate change from wind, solar energy efficiency, and other clean sustainable energy technologies. Moreover, some advanced nuclear fuel cycles, if adopted by the United States and imitated aboard, present new safety, environmental and proliferation challenges that the world in its present state is ill-equipped to handle.

Recommendations about Nuclear Energy Research and Development at the U.S. Department of Energy

The DOE's May 2016 draft "Vision and Strategy for the Development and Deployment of Advanced Reactors" correctly prioritizes addressing the problem of climate change;[15] however in reality advanced non-light water reactor technology is today only remotely relevant to carbon mitigation due to cost, safety and design uncertainties and the very extended roll-out times that would be required. NRDC disagrees with DOE's assessment that "sustaining a substantial nuclear presence in the U.S. power mix beyond 2050 will almost certainly require the development and deployment of a new generation of advanced reactors" given current uncertainties with advanced nuclear and that performance data for the first AP1000 reactors and potentially for the first SMR is still forthcoming and central to this assessment.

In this draft vision and strategy document, DOE has stated a goal of: "By the early 2030s, at least two non-light water advanced reactor concepts would have reached technical maturity, demonstrated safety and economic benefits, and completed licensing reviews by the U.S. Nuclear Regulatory Commission (NRC) sufficient to allow construction to go forward." From

[15] http://www.energy.gov/ne/downloads/draft-vision-and-strategy-development-and-deployment-advanced-reactors

NRDC's perspective this is not a reasonable goal, as it presumes the technical need for and economic competitiveness of advanced nuclear which are far from being demonstrated. Instead, DOE's role for advanced nuclear should be small investments in research and development in areas such as computer modeling and materials science that also have applications for nuclear safety, for nuclear non-proliferation and for non-nuclear energy technologies, such as the use of molten salt for energy storage in renewable generation.

Advanced nuclear reactor designs with their associated nuclear fuel cycles require vigilant attention to nuclear weapons proliferation. NRDC recommends that DOE commission a "red team" study that would seek to exploit the proliferation potential of advanced nuclear energy options, looking at different scenarios –proliferation intent at time of adoption of the advanced nuclear technology, sudden breakout to nuclear weapons capability from a civilian nuclear power program that uses advanced nuclear reactors, or a gradual accumulation of nuclear weapons materials and infrastructure over decades of advanced nuclear power generation leading to establishment of a nuclear arsenal. The nuclear weapons design capacities at the U.S. National Laboratories would be a resource to draw on for such a red team study.

Nuclear energy research and development at the DOE is the spending of taxpayers' money. Given this fact, it is important to consider these DOE programs in the context of substantial existing federal subsidies for nuclear energy. A 2011 study published by the Union of Concerned Scientists[16] found that: "subsidies to the nuclear fuel cycle have often exceeded the value of the power produced. This means that buying power on the open market and giving it away for free would have been less costly than subsidizing the construction and operation of nuclear power plants." Thus, government support for nuclear energy is very broad, and not limited to research and development. NRDC recommends this history should invoke caution from the Subcommittee, as approval of funding advanced nuclear research and development for uneconomical designs can mean taxpayers are then responsible for far greater sums in the future.

[16] Koplow, Douglas N. Nuclear power: Still not viable without subsidies. Union of Concerned Scientists, 2011. http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/nuclear_subsidies_report.pdf

Conclusion

The future of nuclear energy in the United States is uncertain and challenged. In addition to economic challenges for nuclear power, difficulties arise from economics, safety, security, proliferation and nuclear waste, and the value of nuclear power as a low-carbon energy resource is being superseded by advances in energy efficiency and renewable energy technologies.

In consideration of DOE research and development support for advanced nuclear, NRDC respectfully offers five recommendations to the Subcommittee: prioritize solving the nuclear waste problem; assess the prototype AP1000 and SMR before considering further federal investment in advanced nuclear; consistently apply a nuclear weapons proliferation test to advanced nuclear designs; consider the full impacts of severe accidents and the nuclear fuel cycle associated with advanced nuclear reactors; and require greater clarity on the likely economic competitiveness of advanced nuclear designs early in the research and development cycle.

If a public policy goal for Subcommittee members is to preserve the nuclear power option for the United States in the future, NRDC recommends maintaining a healthy dose of skepticism regarding the putative benefits promised by the numerous advanced nuclear technology concepts seeking taxpayer support for their development.