Statement of

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I. Introduction. Co-chairmen and members of the Commission, thank you for providing the Natural Resources Defense Council (NRDC) the opportunity to present its views on the how the nation should proceed in managing and disposing of spent nuclear fuel (SNF) and radioactive high level waste (HLW). 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 has more than 1.3 million members and e-activists nationwide, served from offices in New York, Washington, Los Angeles, San Francisco, Chicago and Beijing. Since its founding NRDC has been involved actively in a wide range of nuclear fuel cycle and advanced reactor research and development issues.

In my testimony today I will focus on five points:

- The membership of the Blue Ribbon Commission (hereafter the "Commission") is not fairly balanced with respect to the range of informed views it encompasses toward the matters within its purview, and therefore is in violation of the Federal Advisory Committee Act (FACA).
- The Commission's priority focus should be on getting the geologic repository program back on track.
- There is a need for a new policy for storage of power reactor spent fuel that ends the practice of dense compaction of spent fuel assemblies in wet pools, and moves spent fuel into interim hardened dry cask storage.
- The single-pass plutonium-recycle fuel cycle as practiced in France should not be adopted by the United States.
- The Commission should oppose investing significant federal resources in a futile attempt to develop uneconomical closed fuel cycles, advance reprocessing technologies and fast reactors, and instead recommend that the substantial ongoing research efforts be redirected to develop non-nuclear technologies that are more likely to mitigate climate change sooner and at lower cost.

II. The Commission membership is not balanced as required by law. First, let me make clear that we do not question the integrity of the members of the Commission, for which we have high regard, and we recognize your dedication to public service. The issue arises from the legal requirement that committees under FACA be balanced in terms of the points of view represented, and from the common-sense view that if you desire to succeed you shouldn't begin by locking out constituencies that you need for success. This commission is not balanced and important points of view are not represented on the Commission.

On April 2nd, we wrote to the Commission's Designated Federal Official about our concerns (see Attachment 1), and on May 19th the Department of Energy (DOE) responded taking the position that the Commission is well balanced (Attachment 2). We believe this issue does not rest solely with DOE and its Office of the General Counsel, but is a matter for the Commission to address. It is the Commission's credibility and fairness that is on the line.

As I'm sure they would acknowledge (as does DOE), there are at least appearances of conflicts of interest for three of the members of the Commission—Mr. John W. Rowe, Dr. Richard A.

Meserve and Mr. Mark H. Ayres. All three have extensive ties to the nuclear industry. Their service without submission to DOE of conflict of interest statements is permissible under FACA, but only provided that the Commission is "fairly balanced with respect to the issues under consideration." It is not balanced.

Mr. Rowe, Dr. Meserve and Mr. Ayres all deserve a seat at the table. But so do others who do not necessarily share their views about the need for additional federal government subsidies for the nuclear power industry.

NRDC, other NGOs and individuals with long interest and sometimes active participation in federal policy related to the management and disposal of nuclear wastes share a range of views from a position that nuclear power should compete for market share without further federal subsidies to the belief that the role of nuclear power should not be expanded due to cost, proliferation, safety and waste management considerations. Many believe further nuclear subsidies carry high opportunity costs in mitigating climate change. The views of these groups and individuals are not represented on the Commission.

For example, Attachment 3 is a statement of Principles for Safeguarding Waste at Reactor Site. This statement was produced and circulated long before the formation of the Blue Ribbon Commission. It is signed by representatives of some 170 national and local groups in 50 states—a very large, thoughtful constituency that are actively participating in matters now under consideration by the Commission. In NRDC's view these groups have essentially no representation on the Commission. The DOE and the Obama administration should have been aware of this statement, the long involvement of many of these organizations in the "issues under consideration" by the Commission, and should have made sure that they were represented on the Commission just as the nuclear industry is well represented.

The Commission cannot expect to be an effective voice in solving the nuclear waste problem if it excludes representation of important constituencies from participating in its discussions and formulating its recommendations. If you expect to reform the process for managing and disposing of spent fuel and nuclear waste, you best not begin by locking out of the process important constituencies whose inclusion is needed to reach a durable consensus on future policy.

III. The Commission should focus on getting the geologic repository program back on track. Regardless of whether U.S. nuclear capacity increases, decreases or stays approximately the same, and regardless of which nuclear fuel cycle is adopted or when, the United States needs one or more geologic repositories for the sequestering of spent fuel and high level radioactive waste for very long periods. Consequently, in our view the highest priority of the Blue Ribbon Commission is to get the repository program back on track. This should be the focus of your efforts and recommendations of your interim report. The issue of what is the preferred future fuel cycle can wait.

Moreover, the DOE-Office of Nuclear Energy's (DOE-NE) FY-2011 budget allocates $195 million for research and development on advanced fuel cycles, exclusive of infrastructure costs. DOE-NE has its own FACA advisory committee, the Nuclear Energy Advisory Committee

(NEAC), and a Subcommittee on Fuel Cycle R&D. It would not be a good use of the Commission's time and effort to review the DOE-NE fuel cycle R&D effort or duplicate the NEAC advisory committee efforts.

With only one geologist among its members the Commission is not properly constituted to recommend preferred geologic repository media or sites. With its more diverse membership, including several former politicians, the Commission could be most helpful if it analyzed what went wrong with the previous processes for siting and licensing a repository in the United States, leading to the proposal to license and then the termination of the Yucca Mountain repository.

This analysis might well begin with Interagency Review Group of President Carter's administration, and then trace the corruption of the site selection process first by DOE and then by the Congress, and similarly trace the corruption of the licensing process by the Environmental Protection Agency (EPA), the Office of Management and Budget (OMB) and again the Congress. In this regard, I offer for your review my own summary of some of these failures in a speech I gave at Vanderbilt University in 2008 (Attachment 4). The Commission also should study the repository programs in foreign countries, e.g., in Sweden and Finland. Given the makeup of the Commission we urge you to focus on process so that we can get the process right the next time.

IV. There is a need for a new spent power reactor fuel storage policy that ends the practice of dense compaction of spent fuel assemblies in wet pools, and moves spent fuel into interim hardened dry cask storage. Fuel pools were originally designed for temporary storage of a limited number of irradiated fuel assemblies in a low density, open frame configuration. Since it is going to be decades before there is a geologic repository, to improve the safety of wet storage of spent fuel we should bite the bullet and decide as a matter of policy to end the practice of dense compaction of spent fuel in wet pools. The Commission should recommend that the Nuclear Regulatory Commission (NRC) establish appropriate licensing criteria for this purpose.

While dry cask storage of spent fuel at existing reactor sites is relatively safer than the operation of the reactors, dry cask storage can be made even safer by storing the dry casks in a hardened building such as the Ahaus Spent Fuel Storage Facility in Germany. The Commission should recommend that the Ahaus approach be adopted at most operational reactor sites and any new off-site interim spent fuel storage facility. The added security of such hardened enclosed storage is worth the small additional cost.

NRDC believes it makes sense to provide for consolidated dry storage of spent fuel from permanently shut down reactors that are not at sites with reactors still operational. This would facilitate decommissioning of shut down reactor sites. NRDC is opposed to off-site consolidation of spent fuel from any reactors at sites where there are operational reactors, because a) it is unnecessary, b) it does not reduce significantly security risks at the reactor sites, c) it increases risks associated with transportation of spent fuel, and d) it reduces the pressure to obtain a geologic repository.

V. The single-pass plutonium recycle fuel cycle as practiced in France should not be adopted by the United States. There are numerous fuel cycle options, but three have commanded the most attention:

1) the once-through cycle and practiced today in the United States;
2) a single-pass recycle in thermal reactors (the French/Areva option); and
3) a balanced closed cycle with transmutation of plutonium and other actinides in fast reactors.

Two issues the Commission will undoubtedly address are: (a) whether the United States should shift now, or in the foreseeable future, from option 1) to option 2); and (b) whether the federal government should continue to invest heavily in research and development on option 3).

We believe the costs to the United States of adopting the single-pass recycle fuel cycle as practiced in France today vastly outweigh the benefits because:

1. The cost of fresh plutonium-uranium mixed oxide (MOX) fuel is several times that of low enriched uranium (LEU) fuel, and this cost gap is likely to persist for decades, if not indefinitely.
2. The commercial development of a closed fuel cycle in the United States would be very costly and would either require massive federal subsidies or a “state-socialist” federal enterprise.
3. It would increase the level of foreign interest and activity, and therefore the proliferation risk, associated with plutonium separation in non-weapon states of concern.
4. The safety and environmental risks associated with reprocessing, MOX fuel fabrication, and managing the larger quantities of low level radioactive waste outweigh the reduction in harms associated with uranium mining, which I acknowledge are significant and need to be addressed directly by significantly improving environmental regulation of uranium mining and recovery operations. But in this case the proposed plutonium cure is worse than the disease.
5. The closed or partially closed fuel cycle results in higher intermediate and low-level radioactive waste including decommissioning waste.
6. There is no significant reduction in geologic repository requirements from moving to an interim single-pass MOX recycle—any such putative benefit is premised on an eventual transition to a balanced fast reactor cycle in which the single-pass stored MOX has remaining fuel value to be extracted.

VI. The wide spread use of fast reactors and a closed fuel cycle to burn selective actinides for waste management purposes has essentially no chance of succeeding within any policy time frame that is relevant to resolving either current nuclear waste storage issues or the problem of decarbonizing the U.S. electric power generation sector. Continued U.S. research and development (R&D) on advanced reprocessing will also fan global interest in plutonium separation and utilization technology and thereby increase nuclear weapons proliferation risks.

Closed fuel cycle schemes to reduce repository requirements typically require that on the order of one-third of the reactor capacity be comprised of fast reactors. The precise fraction is not important here—only to note it is a large fraction. To achieve such a balanced ratio of fast to thermal reactor capacity in the United States in the next few decades would require roughly that the next 50 gigawatts-electric (GWe) of reactor capacity built in the United States to be fast reactors, e.g., 50 fast reactors each about the average size of U.S. nuclear power reactors operational today. The Commission should acknowledge the fundamental reasons why this outcome is highly unlikely in the next few decades or for that matter in this century.

History has not been kind to fast reactors. They have cost considerably more than thermal reactors, and seem likely to stay that way, and have proven to be much less reliable than thermal reactors.

Commercial fast reactor development programs failed in: 1) the United States; 2) France; 3) the United Kingdom; 4) West Germany; 5) Italy; 6) Japan; and 7) the Soviet Union/Russia. After spending on the order of $100 billion current dollars on fast reactor development there is only one operational commercial-size fast reactor out of about 436 operational commercial power reactors worldwide and even this one at the Beloyarsk Nuclear Power Station in Russia is not fueled with plutonium. Despite decades of state-socialist support, Russia has not fully closed its fuel cycle. The fast reactor program in India is not showing any signs of success, and the program in China is at a very early stage, although China is preparing to purchase two BN-800 fast reactors from Russia. (For a more complete history of the fast reactor programs in the United States, France, United Kingdom, Russia, Japan and India, see Thomas B. Cochran, Harold A. Feiveson, Walt Patterson, Gennadi Pshakin, M.V. Ramana, Mycle Schneider, Tatsujiro Suzuki, and Frank von Hippel, "Fast Breeder Reactor Programs: History and Status," International Panel on Fissile Materials, Research Report 8, February 2010, available at http://www.fissilematerials.org.)

The U.S. and Soviet navies also tried to adopt fast reactors for naval reactor propulsion, but these programs were failures as well. In the view of Admiral Hyman G. Rickover, fast reactors were "expensive to build, complex to operate, susceptible to prolong shutdown as a result of even minor malfunctions, and difficult and time-consuming to repair."[1]

Admiral Rickover got it right, and this has been the history of fast reactors. One need only review the experience of the flagship fast reactors in the United States, United Kingdom, Germany, and Japan. The U.S. *Clinch River Breeder Reactor* experiences huge cost overruns well before it was cancelled in 1983. The French *Superphenix* operated only eleven years at an average capacity factor between 6 and 7 percent. The U.K's Prototype Fast Reactor (PFR) experienced problems with its steam generators. Japan's *Monju* demonstration reactor, which was recently restarted after being shut down for 14 years following a small sodium leak, now has a lifetime capacity factor of less than one-half of one percent.

The Soviet navy adopted lead-bismuth cooled fast reactors for its Alfa Class submarines; but then like the United States the Soviets abandoned fast reactors in favor of pressurized water reactors for naval propulsion.

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[1] Richard G. Hewlett and Francis Duncan, *Nuclear Navy: 1946–1962* (Chicago: University of Chicago Press, 1974), p. 274.

VII. Nuclear Economics.

Fuel Costs. Like most major minerals, the improving efficiency of uranium extraction has kept pace with the depletion of accessible, known reserves and the costs of finding new reserves. If this trend continues the constant dollar cost of uranium extraction is likely to remain about what it is today or possibly even decline somewhat. This is not to say that there will not be significant short term price fluctuations due to temporary supply-demand imbalances in the global uranium market, as occurred in the mid-1970s and again three or four years ago.

In 1960 the Atomic Energy Commission (AEC) was paying $8.85 per pound of U_3O_8.[2] Using the GDP deflator index, that price would be six times this amount in today's dollars, or $53 per pound of U_3O_8 ($138/kg U). Over the past year monthly spot uranium prices fluctuated between about $51 and the current value of just over $40 per pound of U_3O_8. Prices have been descending following a very sharp short-term increase.

The other principal component of the cost of low enriched uranium (LEU) fuel is the cost of enrichment. On July 1, 1962, the AEC charge for enriched UF_6 reflected a charge of about $30/kg SWU, equivalent to $175/kg SWU in 2010 dollars.[3] I suspect the actual cost was much higher and the charge did not reflect the entire cost of constructing the gaseous diffusion plants. In any case, the price of SWUs today is about $160/kg SWU, so SWUs costs have not increased appreciably in over the past 50 years.[4]

In 1970, reprocessing costs were on the order of $30/kg, the equivalent of about $140/kg in 2010 dollars, and the AEC was predicting reprocessing costs would go down. Today, in real terms reprocessing costs are more than an order of magnitude higher than they were 40 years ago.

In the 2003 MIT report, "The Future of Nuclear Power," the cost of a MOX fuel was estimated to be $8,890/kg, some four times greater than the cost of LEU fuel, $2040/kg, or 2.24 cents/kWh versus 0.515 cents/kWh.[5] Assuming this 1.725 cent/kWh cost differential and that one out of eight fuel assemblies are MOX assemblies (where the plutonium recovered from reprocessing 7 spent LEU fuel assemblies is used to make one MOX assembly), U.S. consumers would be paying $1.7 billion/year more for their electricity today, or $70 billion more over 40 years.

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[2] **"**Prior to April 1, 1962, all domestic uranium mills operated under negotiated-price contracts with the U.S. Atomic Energy Commission. The prices paid under these contracts varied with the grade of the ore handled and with the cost structure of the individual mills. The 1960 average was $8.85 per pound of U_3O_8 or equivalent, and in that year sales to the AEC approximated $300 million. Starting April 1, 1962, and continuing through December 31, 1966, the AEC will purchase mill concentrates at a guaranteed base price of $8.00 per pound under contracts that will specify production rate, ore source, and related matters." John F. Hogerton, *The Atomic Energy Deskbook* (New York: Reinhold Publ. Corp., 1963), p. 586.

[3] John F. Hogerton, *The Atomic Energy Deskbook,* p. 582.

[4] From FY 1971 to FY 1982 the AEC/DOE's cost of enrichment at the three gaseous diffusion plants gradually increased from $23.80/kg SWU to 102.62/kg SWU, the equivalent of about $105/kg SWU to $190/kg SWU in 2010 dollars. AEC, "AEC Gaseous Diffusion Plant Operations," January 1972, p. 17, and DOE, "Uranium Enrichment, 1983 Annual Report," ORO-842, pp.28-29.

[5] Massachusetts Institute of Technology, "The Future of Nuclear Power: An Interdisciplinary MIT Study," 2003, Appendix Chapter 5 — Economics.

In sum, barring an explosive global nuclear demand growth scenario that permanently outstrips the capacity of uranium suppliers to keep pace—leading to a long term secular upward trend in prices like the one we have seen in the petroleum markets since 1999—LEU fuel costs in real terms are unlikely to increase significantly for many decades and MOX fuel will remain non-competitive with LEU fuel.

Capital Costs. In 1968 the AEC was pegging the capital cost of light water reactors (LWRs) at $150/kW and predicting that it decrease to about $125/kW by 2000, or in today's dollars from $770/kW in 1970 to $640/kW in 2000. These historical nuclear capital cost estimates were too low by roughly an order of magnitude. In 1968, the AEC also estimated that the capital cost of a liquid metal fast breeder reactor (LMFBR) would be about 20% higher than that of an LWR, but the cost differential was projected to shrink to zero by about 2015. Today, LWRs cost $4,000/kW to $9,000/kW and the estimated LMFBR-LWR cost differential is greater than 20%. Thus, the cost differential between a LWR and a fast reactor is likely to be some multiple of $1000/kW, which translates into a multiple of 1 cent/kWh. For a 50 GWe fleet of fast reactors operating at 90% capacity factor—needed to balanced 100 GWe of thermal reactors in a closed fuel cycle for actinide burning—the added cost over 150 GWe of LWR capacity would be some multiple of $4 billion/yr, or one to several times $160 billion over 40 yrs. To this one must add the higher closed fuel cycle costs—an added cost of more than $100 billion over 40 years.

Plutonium recycle and the introduction of fast reactors would contribute nothing toward the decarbonization of global electricity supplies for many decades, while consuming valuable capital resources better spent on less costly and more practical energy alternatives for climate change mitigation. Continued research into actinide recycle could encourage the development of hot cells and reprocessing R&D centers in non-weapon states of concern, as well as the training of cadres of experts in plutonium chemistry and metallurgy, all of which pose a serious proliferation risk. Essential predicates for introducing plutonium fuels and fast reactors on a large scale must include not only reliable technology and sound economics, but also an international nuclear security and nonproliferation framework that is far stronger than the one that exists today. And finally, for those who take the long term prospect of nuclear disarmament seriously, I would note that premature proliferation of closed nuclear fuel cycle facilities, without such a robust framework in place would effectively doom prospects for global elimination of nuclear weapon arsenals.

VIII. Concluding remarks. Faced with a host of more urgent budget and R&D priorities related to decarbonization of our energy supply system over the next several decades, NRDC opposes spending additional federal resources on technically dubious and economically inefficient schemes to further develop or deploy closed fuel cycles, advanced reprocessing technologies, and fast reactors. We support research toward developing incremental improvements in the once–through fuel cycle, particularly improvements in air-cooling systems that could diminish the significant ongoing and future impacts of nuclear reactors on freshwater resources and marine life, and most importantly we support getting the geologic repository program back on track.

Plutonium is currently a valuable resource for nuclear weapons, but not for nuclear energy production. It has a negative economic value for this purpose and we see little prospect that this will change in the foreseeable future because there is no evidence that uranium resources are likely to become scarce in the world, or even in those countries that are closely allied with the United States.

In 1944, when Enrico Fermi, Leo Szilard, Eugene Wigner, Alvin Weinberg and others gathered at the Metallurgical Laboratory in Chicago to discuss the possibilities for using nuclear fission to heat and light cities, uranium was scarce and so they proposed to use plutonium breeders. Today many nuclear engineers refuse to learn some of the most important lessons from the subsequent 66 years of nuclear developments. They are still living the dream of Fermi, et al.—hanging onto the notion that *someday* civil plutonium use will become economical, and therefore we should continue to spend hundreds of millions or billions of dollars annually preparing for the imminent arrival of the closed nuclear fuel cycle. While no one can say definitively that this “someday” will *never* come, we are clearly talking about a period of at least several and more likely many decades from now before the economic and international security calculus begins to shift in favor of this option.

In the meantime, all that spent fuel isn’t going anywhere. It will continue to sit there in wet pools and dry casks, preserved for possible use by or harm to future generations. This Commission is not properly constituted to be making a recommendation as to whether it is in the best interest of future generations that spent fuel be disposed of permanently or retained for possible use generations from now. At the very least the Commission should not take up this societal issue unless it is prepared to review the literature on the theory of justice and the intergenerational transfer of risks related to nuclear power. One would hope that the Commission could focus its attention on more practical possibilities for arriving at a social and political consensus on some of real issues that confront nuclear power, spent fuel management, and nuclear waste disposal over the next few decades.