Summary Statement of

Christopher E. Paine
Director, Nuclear Program,
Natural Resources Defense Council, Inc.

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Natural Resources Defense Council, Inc.
1200 New York Avenue, N.W., Suite 400
Washington, D.C. 20005
Tele: 202-289-6868
cpaine@nrdc.org

Co-chairmen and members of the Subcommittee, thank you for providing the Natural Resources Defense Council (NRDC) the opportunity to present its views on the advantages and disadvantages of new nuclear fuel cycles. 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 engaged in a wide range of nuclear fuel cycle and advanced reactor research and development issues.

The Subcommittee has asked that I address the following three questions:

1. What are the performance criteria by which nuclear fuel cycle options should be compared?

2. How should these performance criteria be weighted to make useful life-cycle assessments of costs and benefits of fuel cycle options (including weighting of criteria related to repository capacity and waste disposal costs)?

3. What actions could facilitate development and deployment of new reactor and fuel cycle technologies that would better meet these performance criteria?

Before attempting to answer these questions, I would like to say a little bit about the broader policy context in which these questions are being posed, including the design of the overall sustainable energy supply system into which the nuclear fuel cycle must comfortably fit. In my view all too often discussions about future nuclear fuel cycles occur in an economic and energy policy void where all that matters are the alleged technical advantages of the nuclear technologies under review. The economic rationality, broader benefits, and collateral risks for society and the environment are often neglected, when these are the essential questions.

Going forward, all nuclear fuel cycle options, and indeed all available technologies that can supply energy services, should be measured against five primary criteria:

(1) Does the technology present a cost-effective path for abating carbon emissions relative to other available low-carbon energy technologies?

(2) Given the reality that carbon emissions accumulate in the atmosphere, and therefore abatement options have a time value, how soon can the technology be deployed compared to other low-carbon options?

(3) What are the harmful *non-carbon* environmental impacts of the technology compared to other available low-carbon technologies, and can these impacts be sufficiently mitigated to permit wider use?

(4) Is the technology socially and geopolitically sustainable, by which I mean, can it be implemented and replicated without displacing human populations, destroying communities and cultural resources, triggering harmful macro-economic effects on vulnerable populations, aggravating regional security concerns, or invoking invidious distinctions between nations?

(5) What other electricity resources will the technology either support or displace on the grid, and how will this affect the overall rate at which genuinely clean renewable energy and efficiency resources are deployed?

It should be obvious that these criteria will not often lead to a clear binary decision, yes or no, on a given energy technology option, but rather to a rank ordering of options that suggests what to invest in now, and what to defer until environmental mitigation advances, further technical innovation, or institutional change remove a sufficient part of the downside to render them acceptable.

So let me, briefly, apply these criteria to the fundamental nuclear fuel cycle choices before this committee, DOE, and the country, and see where that leads us.

With respect to the first criterion, cost-effectiveness in cutting carbon, I think everyone on the BRC understands that, from the new-build perspective, all full and partial re- cycle options are very distant from the cutting edge of cost-effectiveness in reducing carbon emissions. The only nuclear fuel cycle option even in the running today is the current LWR open cycle. But electrical end-use efficiency, waste-heat cogeneration, combined heat and power systems, wind, and bio-gas are currently cheaper and faster targets for new carbon-reducing investment than new-build LWR's.

Adding a $25 billion reprocessing plant, MOX recycle, and a fast reactor development program would add nothing to nuclear power's decarbonization potential over what might be achieved with LWR's alone, and would represent a heavy tax on the national decarbonization effort for at least several decades, if not indefinitely.

I believe that within a few years, before construction of the first nuclear new build is even completed, solar PV and solar thermal plants will be competitive with nuclear new build for supplying intermediate and peak load electricity. At a forecast $2000 per kWp installed cost for solar PV by 2015, grid parity for solar will be achieved in many electricity markets around the world, including parts of the U.S., and solar is going to become an ubiquitous feature of our electricity supply system. This does not mean that solar and wind will displace nuclear, but rather that nuclear will be operating in the future on a grid with a high market penetration of variable renewable sources, which has implications for the type of nuclear plants we should be looking to build. I'll come back to his point in a moment.

With respect to the second criterion, the relative time value of alternative low-carbon investments, large new-build LWRs have historically required on average 6-9 years to construct, and even longer when the entire project development timeframe is considered. Almost every other low-carbon energy technology beats nuclear on this criterion. During this long gestation period, power is being procured from carbon-emitting sources and the low-carbon nuclear asset is not producing.

Adding reprocessing facilities and fast reactors to this mix would only further delay nuclear's contribution and adds to a nuclear project's carbon debt. Japan's Rokkasho reprocessing plant, for example, has been under construction for 17 years, costs more than $20 billion, and commercial operation has been postponed until October 2012. This criterion suggests that DOE should focus its development support on more cost-effective LWR's with reduced construction times and/or modular plants that can begin generation within three years and add "bankable" capacity increments when they are needed.

My third criterion involves assessment of non-carbon environmental impacts of various nuclear fuel cycles compared to each other and to other low-carbon options for supplying electricity services. The current nuclear fuel cycle is preferable to coal mining and burning in this respect, even if, in my view, the carbon emissions from the latter are largely captured and sequestered. But achieving carbon capture and disposal on a wide scale any time soon does not seem likely, so that in my view gives nuclear a decisive environmental edge vis a vis coal. But of course that is not the end of the comparison. The current nuclear fuel cycle does not fare nearly as well when its life-cycle environmental impacts are compared with a wide range of renewable energy options, which likewise have environmental impacts of their own that must be considered and compared.

Again this obviously doesn't mean that one should discard nuclear as an option, but only that, based on this criterion, its near-term investment priority for the nation should be somewhat lower than cleaner renewable technologies and energy efficiency, and the near-term R&D focus should be on reducing these non-carbon environmental impacts, which include mill tailings that leak radon and heavy metals, pollution of aquifers mined by the in-situ-leach (ISL) uranium mining technique, overheating of inland freshwater bodies and coastal estuaries, huge fish kills in cooling intakes, massive consumptive use of freshwater for evaporative cooling, and tritium leaks from operating reactors and spent fuel storage pools. And then, of course, there is the task of storing and ultimately disposing of spent fuel and other nuclear waste forms, a task that, with patience and good will among all the parties involved, I view as eminently soluble.

In theory, a full implementation of the closed fuel cycle could significantly reduce uranium mining impacts, but this would only occur if the shift to a closed fuel cycle occurred on a large scale and led to a significant dimunition in global reliance on the open cycle, rather than merely an additional deployment alongside it. In any case, such a shift seems an exceedingly distant prospect in economic terms, and there are obvious international security concerns that would have to be dealt with first, so the non-carbon environmental impacts of the current LWR fuel cycle are likely to be with us for quite some time.

This suggests that to make nuclear power a more relevant decarbonizing option, DOE and NRC should address these environmental liabilities in the near term and make a serious effort to reduce them within the context of the LWR fuel cycle, and not waste money foraging about for implausible closed fuel cycle options that are justified primarily by their alleged and very distant abilities to reduce future repository requirements.

Regarding the forth criterion, social and geopolitical sustainability, I think it's clear that far-reaching institutional innovations are needed in international nuclear cooperation and governance before we can feel at all comfortable about promoting substantial reliance on the closed nuclear fuel cycle, or even cooperative research and development with non-weapon states that involves significant tech transfer in support of this goal. The US government is already tied up in knots when we confront the problem of making invidious and politically unsustainable distinctions between states regarding their access to sensitive enrichment technology – witness the current complicated dance State and Energy are doing over the respective draft Sec. 123 agreements with Jordan and Vietnam.

Even if we decide that the most prudent path forward is continued reliance on the LWR cycle, this path will still entail weighing the potential harms and benefits to the indigenous and local communities whose lands are being mined or at risk of contamination. And it will continue to pose a continuing international security risk from the spread of uranium enrichment facilities operated under purely national auspices, or possibly even in secret.

So irrespective of the fuel cycle option chosen, this criterion suggests that international institutional innovation to provide stronger nonproliferation assurance is urgently needed, and that the US government needs to pay a lot more attention to this issue, and soon.

Finally, let me say a word about the fifth criterion, which relates to the effect a proposed energy technology has on the future design and operation of the power grid as a whole. When we talk about the future of nuclear power, we don't talk enough about the kind of overall electricity supply system that we are implicitly or explicitly believing nuclear power will support. A transition to a decentralized network of locally supplied micro-grids, in which most communities generate most of their electricity locally, will have different implications for future nuclear power development than the highly centralized power generation network we have today, with its extensive reliance on large "baseload" central station generating units and high voltage transmission lines.

Or consider a series of connected regional grids, each with a high percentage of variable solar and wind generation that requires the use of flexible, immediately responsive generating and/or energy storage assets to "follow the load" and fill in the gaps. Where do large central station nuclear plants fit in this scenario? If large federally guaranteed nuclear units are added to the grid, and must operate at a high annual capacity factor to recoup their costs, which existing or future electricity resources will they end up displacing? Will it be dirty base load coal plants, or further investments in less-costly energy efficiency and industrial waste-heat cogenerating assets (in order to maximize sales of the reactor's electrical output)?

If the new reactors have excess capacity at night, will that be used to recharge legions of electric vehicles, or result in taking cleaner, less costly wind generation off line. Will the presence of the new reactors ultimately accelerate or inhibit further additions to the grid of clean distributed generating assets, like solar rooftops, community wind, and fuel cells running on landfill gas and "cow power?"

Rather than debating the future evolution of the nuclear fuel cycle in isolation, we should be discussing it in the context of alternative grid paradigms and then concrete plans for transforming the energy sector of the nation into an environmentally sustainable configuration, and considering how and where nuclear power can best assist that *overall* transformation. The Department of Energy needs an indicative National Energy Plan that aggregates sustainable energy plans developed within and for each regional grid within the country, as each region has a different balance of potentially cost-effective low-carbon energy resources. Some regions may decide their future plans don't need to include either coal or nuclear power, and that they can proceed to a low carbon energy future based on a future of efficiency savings, traditional hydro, renewable energy, and natural gas. Other regions may foresee a continuation or even expansion of nuclear power as coal combustion phases down.

But in all cases, application of the preceding criteria suggests that we are talking about the current LWR cycle -- or possibly innovative extensions of it, such as thorium substitution in standard fuel assemblies, or Small Modular Reactors -- as the primary focus of the nuclear fuel cycle's continuing contribution to decarbonization.

Nuclear power technology has been around for a long time. Globally hundreds of billions of dollars have been expended on developing it. At this point I think it's fair to say that the likelihood of uncovering a new, truly transformative, non-proliferative, waste –transmuting and compellingly economical nuclear fuel cycle is very low. My longtime colleague Dr. Thomas Cochran has been known to say that chance is zero.

I won't go quite that far, but I think the rational ordering of priorities is very clear, and that significant investment in developing new closed fuel cycle options is both unwarranted and unwise. Research should be limited to education, basic science, e.g., materials science, computational simulations, and systems studies focusing on the economics and nonproliferation aspects. The research should be chosen from a competitive peer-reviewed competition.

Meanwhile, the environmental need to de-carbonize is urgent, and we have a number of proven and emerging technical opportunities for doing so that cost far less and are available sooner than *any closed nuclear fuel cycle option.* The real challenges for those who believe in the continuing relevance and potential of nuclear power in a decarbonizing energy system are to reduce the capital cost and environmental burdens of the current open cycle technologies, store spent fuel above ground securely and responsibly, resume a technically and politically legitimate process for identifying one or more permanent underground nuclear waste disposal site, and support the development of a more effective nuclear nonproliferation regime.

For historical and institutional reasons – the "technical DNA" of its nuclear energy research laboratories in particular -- DOE-NE has focused on development of fuel cycles that will drive up the cost of nuclear electricity, and not on reducing the capital costs of new nuclear power plants by fostering innovations in the way nuclear power plants are designed, manufactured, and assembled at the site. The priority is wrong. To reduce the cost of something, you have to systematically reduce the cost of the materials, machines, and processes you use to produce that something. Simply subsidizing the deployment of the same finished product will not lead to a significant reduction in its cost, and indeed, we observe no historical learning curve cost reduction for nuclear reactors as we do for other energy technologies.

So these are my five criteria and how I would apply them to the choice of nuclear fuel cycles, and to the choice between nuclear power options and other low-carbon technologies. I see no valid reason for adopting a separate set of criteria in order to choose between nuclear fuel cycle technologies.

You ask in question two how one would weight these criteria in making the choice between the present LWR and potential closed fuel cycle options. The most important criteria to consider in this comparison are the cost-per-ton of CO_2 avoided (#1) and proliferation risks (#4). They are both important, but as for weighting them, an advanced fuel cycle option that produces electricity at less cost than the current LWR cycle, but poses a greater proliferation risk, would be unacceptable, while an advanced fuel cycle option that costs more but significantly reduces proliferation risks -- a very tall order given the sensitive technology base that normally transfers with adoption of closed fuel cycle techniques – would in my view still be worthy of examination in a severely carbon constrained world.

But I view this latter possibility as likely to arise only in the context of a far reaching transformation of the international framework for nuclear fuel cycle cooperation, in which case new institutional arrangements, rather than the fuel cycle technology itself, are more likely be the primary source of the reduction in proliferation risk.

Finally, the third question asks: "What actions could facilitate development and deployment of new reactor and fuel cycle technologies that would better meet performance criteria? In the course of discussing each of my performance criteria, I believe I have mentioned the need for practical actions that could be taken to:

-- Reduce the harmful environmental impacts of the current once-through fuel cycle (e.g. uranium mining impacts, thermal discharges, consumptive water use, fish kills)
-- Develop a more robust international framework for reducing proliferation risks;
-- Place domestic interim storage and long term disposal of spent fuel on a sound technical and political footing; and
-- Examine how the integration of new large LWRs may affect the addition of renewable and distributed low-carbon generation to the grid, and whether more flexible, cost-effective LWR units capable of responsive load-following could better support a high level of market penetration for variable renewable energy resources.

While the balance of activities in DOE's current "Nuclear Energy Research and Development" Roadmap represents an improvement from previous plans, it does not appear sufficiently focused to affect commercial nuclear power's ability to supply low carbon energy services at competitive cost, while minimizing the current fuel cycle's harmful environmental impacts. I hope the Commission will be able to exert a practical and constructive influence on these matters.

Many thanks for inviting me, and I would be pleased to respond to any questions you may have.