Nuclear Energy at a Crossroads[1]

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CSIS, October 2016

Today's meeting is titled "nuclear energy at a crossroads." Yogi Berra had famous advice for those at crossroads: "If you come to a fork in the road, just take it." I don't know if that's the situation we're in, but I do think we have a set of deliberate choices that we have to make in roughly a five-year period.

I'm going to talk about eight developments. First I will name them and say why I think they are important and present a roughly five-year window for some action, even though many of them have much longer timescales in their evolution going forward.

Number one in that list—not surprising—is the fate of existing nuclear plants and the implications for carbon emissions. I'm assuming this is a very knowledgeable audience so I'm not going to give a lot of the background on this issue. You all know about the closure of various plants. Since 2013, 6 nuclear plants have closed, and 12 more announced their intention to close before their operating licenses expire. Let me put these closures in the context of the Clean Power Plan, which does have a five-year timeframe.[2] The 2018 implementation plans are to come into force in 2022. I'm assuming, of course, that the current litigation will be resolved in a way that the Clean Power Plan does move forward on that timescale. But there is now this irony. This set of closings is significantly complicating this planning exercise and developing a need for a real transition plan, especially in certain parts of the country. We have to face up to the states coming forward with their implementation plans and then having their options narrowed. There is no agreed way to approach that problem. Nuclear power is responsible for 60 percent of the United States' carbon-free electricity, and as states seek to reduce their emissions further going forward, the chances of reaching deeper levels of decarbonization are much less if states have to fill the gap left by prematurely retiring nuclear power plants. We all know about New York and Illinois' innovative attempts to preserve their plants. I'll comment on these more later.

Second, an important development within the next five years is that we will have the four new plants in the Southeast coming online. Watts Bar 2 has already started up. I think the really important question in the path forward will be getting a final resolution of the cost performance and scheduled cost recovery for those plants.[3] We already know that there will be mixed reviews. These first two points—the closure of plants, notably in the Northeast and Midwest, and the building of these new Gen III-plus plants in the Southeast—starkly call into the discussion how different regulatory

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structures and cost recovery in the United States are central to what we can see going forward in nuclear power.

Third point. If nuclear plants today retire, or at least mostly retire at 60 years, then the big wave of retirements really starts coming after 2030. However, in the utility business, capital allocation decisions occur on a decadal timescale. In other words, within the next five years we are going to have to start seeing many more utilities facing up to those large capital planning decisions if they are to seek license extensions to go to 80 years. It would be an enormous undertaking to shift that 2030 date to beyond mid-century. With what we know today, we would have to say that there are some pretty big investment choices to be made in a roughly five-year time schedule.

Fourth is we need to develop a reliable, resilient, decarbonized electricity system. It's critical to meeting environmental, economic, and security goals. In fact, a decarbonized electricity system in any credible model is the lead horse for a deeply decarbonized energy system. But frankly, what that system will or should look like is extremely unclear. For one thing, there remain enormous open questions about the valuation of different services and different characteristics of the system that have tremendous implications for nuclear power. What is the value of fuel diversity? What's the value of baseload? What's the value of capacity? What's the value of storage? Etc.? Our second installment of the Quadrennial Energy Review at least defines those valuation questions. But frankly one can already see a system where nuclear power is essential for a deeply decarbonized sector. We will say it's essential, but that by no means is a universally held view. There is certainly the view that energy efficiency, combined with wind, combined with solar, combined with natural gas to balance those variable renewables, at least in the nearer term and eventually maybe heading to economical large-scale storage, will be the system. No need for baseload. Again, I'm not endorsing that view, but that is a statement made quite regularly. So these are very, very different views with enormous implications for nuclear. I believe that we do need to maintain optionality. I also believe that the directions in which we are going, given the long time constant for infrastructure investments in this business, is again going to be a five to ten-year issue to be resolved.

Fifth, there is the back-end: spent fuel management. Here I think the situation that we are in—and have been in for some time—is a significant headwind for many decisions in the nuclear space. Certainly in various states and with various utilities. And here the issue of getting on with the job of moving spent nuclear fuel away from utilities is central. I continue to believe that consolidated storage, sometimes called interim storage, is absolutely essential no matter when a geological repository is realized; interim storage should be part of the system. It's something that we can move on quickly. And quite literally, if Congress acted to give us the authorities, we could have a pilot interim storage facility running in not much more than five years, whether it's public or privately held. So that's another major issue that could and should be decided in the next five years.

Sixth, let's consider the nuclear fuel cycle and nonproliferation arena. First of all, a couple of major developments highlight the importance of these issues. There are continuing active discussions about reprocessing in Northeast Asia. The Iran deal highlights the issue of how nuclear energy developments globally presents nonproliferation challenges. I think this is a familiar point to this audience but nevertheless deserves repeating: the role of U.S. companies in global nuclear supply

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chains really is an important, indeed a very important, pillar for what we do in the nonproliferation regime. In many ways, the "123 agreements" are the foundation. If we aren't involved in the nuclear supply chain, these agreements become less compelling instruments for discussion. So this is very important. We know that we are challenged without a major domestic market. Nonproliferation norms through both bilateral and multilateral organizations certainly are helped very much by an active and high-quality nuclear industry in the United States.

Seventh, let's talk about small modular reactors (SMRs). We expect the first of these to go through Nuclear Regulatory Commission (NRC) licensing in this decade and potentially be deployed in the following five years or so. I think a real question is going to be understanding their cost performance parameters in the real world. Perhaps the most critical issue for the subject we are discussing will be the extent to which opportunities are developed for different financing structures for these nuclear reactors. If you look at the capital costs for wind and solar weighted by their capacity factors, they and nuclear are potentially in the same ballpark. But, with wind and solar, obviously, you can get modular wind or solar farms. A 100 megawatt (MW) scale is a nice number. Now there also are, of course, financial incentives for renewables, and that's one of the discussions worth having about a more technology-neutral, low-carbon/zero-carbon environment. But the fact is the capital costs per unit of capacity weighted by what matters, the cash flow, is not very different. For solar, just last week the largest federal purchase of renewable energy was celebrated, and that was something that the Department of Energy (DOE) collaborated on with the Navy. The Navy provided a procurement planning agreement for 150 MW of solar built in Arizona to supply 14 navy and marine instillations in southern California. It provides attractive costs, a stable cost profile that has a lot of value for planning purposes, and is available in a nice chunk. I would say all of those advantages apply as well, at least potentially, to a small modular reactor. Again, the next five years is going to be an important period for that.

Finally, number eight. In the context of new reactors, there is a lot of interest for the much longer term, let's say 2040 and beyond. My advisory board's enthusiastic members, including Chairman John Deutch, seem to think 2030 is possible. Molten salts, high-temperature gas-cooled reactors, fast neutrons, you name it, could be very attractive in the longer term. But, I would argue again there's a short-term decision. The Secretary of Energy Advisory Board report[4] that was published a few weeks ago basically was given the charge of answering the question about what would it take in terms of federal support to have a credible chance, working with the private sector, to develop some of these advanced reactors and bring them to the marketplace in 2040 and beyond. The simple part of the answer is that it would take at least $0.5 billion per year of federal support over an extended period for that to happen, and it's a long time period. This means if you want to get there by 2040, you would have to start yesterday in effect. I note that on the first day of the Paris meeting we announced Mission Innovation, where 20 countries (now 23), with President Obama leading the effort, announced the intent to double energy research and development (R&D) over a five-year period. I mention that because the DOE nuclear energy program has got a $500 million to $600 million R&D budget; if we just notionally double that to $1 billion or even to $1.5 billion a year, suddenly we would have a program that can include advanced reactor development in addition to life extension, SMRs, and nuclear waste issues. Suddenly it becomes possible. That's an example of how opening up that innovation pipeline will affect many areas of the department's portfolio, and that would include

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nuclear energy's advanced technologies. That Mission Innovation challenge is to get the budget doubled over the next five-year period. There is strong bipartisan support to do that, but the challenge is to get that enthusiasm to match the budget numbers.

So those are eight areas where, I think, going back to the crossroads theme, we really have an exciting period ahead of us. Frankly, a very significant number of those have to break right to have a strong nuclear power prospect of the scale that will be material in meeting carbon targets, strengthening the nonproliferation regime, and the like. Derivative of those, I note that there are three areas that we can talk about as providing the underpinning for why public engagement, public funding, and public incentives should be advanced for nuclear energy. One is obviously climate and the decarbonized electricity sector, as we've already discussed. It's absolutely essential that we address this deep decarbonization challenge and that electricity be the lead horse in doing so. Just note that it's been a hell of a year for climate. We talked about the Paris Agreement. It's coming into force next week. Just a week before last we had the meeting in Rwanda on hydrofluorocarbons, and then, of course, there is the Mission Innovation initiative that I mentioned. There's a tremendous amount of momentum, but now we have to fund it and move forward. While climate is the clearest underpinning in my view for strong public policy in this arena, industry, frankly, has to have a clearer voice in supporting that position. That has not been the case to date, to put it bluntly. So the industry has got to step up and acknowledge the importance of this and not be too cute by half.

The second basis for public support is about nonproliferation and nuclear supply chains. I mentioned the Iran Agreement in passing, but just note that the agreement did go into some new directions in terms of safeguards that may or may not be a harbinger of future development in the safeguards arena. All of us, including industry, have to acknowledge this interplay between the proliferation agenda and energy agenda. It is real and frankly provides a motivation for a strong domestic nuclear energy technology program.

The third area is one where it's less clear in the current discussion. Another motivator of public policy is what I might call the risk management of electricity system evolution. There is an imperative need for a reliant, resilient, twenty-first-century grid. The importance of that electricity system development is completely clear because you can make the simple argument that just about every infrastructure depends on two other infrastructures—electricity and telecom—and indeed the further integration of those two is going to be a signature of how our system evolves. We have a set of technologies that includes nuclear and renewables, which are essentially "high capital, low operating costs." The question is what risks are we undertaking by mixing that system with what are basically low-capital and high-fuel-cost risk technologies based on natural gas? Today, natural gas is growing so rapidly because it has low capital costs <u>and</u> low fuel costs. But I think building a system around a dominant role for natural gas going into the future is not an exercise in proper risk management in terms of exposure to the unknowns of future fuel costs. We face highly distributed decisionmaking in this sector and a fragmented regulatory regime that makes this kind of risk minimization and system optimization very, very difficult to achieve. This is a critical public discussion about options and values, and it is one that I think if done properly could be a third pillar of the importance of public engagement in promoting the nuclear energy sector.

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Now I have additional thoughts on each of these eight. But let me bring out just a few for emphasis. One is the issue of existing nuclear plants. In the end, interactions with the states is absolutely critical—that's where a lot of the action is. I had John Kotek, head of our nuclear energy program, and Dave Foster, our senior adviser for job strategy, go out to Illinois for a meeting hosted with labor unions to help that discussion. And mentioning labor unions, this is also important for infrastructure and jobs. In my view, we have not done enough to put a jobs strategy at the core of a climate strategy. I think that is something worth thinking about a lot more. Frankly, it's something that can be of quite some relevance in the nuclear sector. We also hosted a meeting on Capitol Hill on this question of extending current reactors. On life extension, we have a whole bunch of programs. I won't mention them in detail, but they remain critical for the reasons we said earlier to push out a major potential retirement wave of nuclear plants to mid-century. On spent fuel, we continue to emphasize, whether it's storage or repositories, that consent-based sighting is essential. We never said it would be easy, but we just aren't going to get there without it. Once more I will mention the importance of storage options as something we can move quickly on. It's time to stop having that held hostage to other issues, because this is a critical five years, and we are just going to mess up a whole bunch of important decisions in this time period if we don't move forward. With that I'll skip the rest of my comments and engage in some discussion. Thank you.

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[1] This paper is a transcript, edited for clarity, of a presentation delivered at the Center for Strategic and International Studies (CSIS) in October 2016. Additional notes point out developments as of July 2017 that are directly relevant to the narrative.
[2] The Trump administration has announced its intent to terminate the Clean Power Plan, while acknowledging the Supreme Court ruling that the Environmental Protection Agency must regulate CO2 under the Clean Air Act. The courts have not yet ruled, and the administration has not offered its alternative. In this unsettled situation, as many as 20 GW of nuclear capacity are thought to be at risk of premature closure by 2020, which would likely lead to a significant increase in CO2 emissions.
[3] The ongoing bankruptcy proceedings of Toshiba/Westinghouse as of July 2017 has created uncertainty about the path forward for current new plant construction in the United States and therefore about the cost and schedule performance.
[4] Secretary of Energy Advisory Board, *Report of the Task Force on the Future of Nuclear Energy* (Washington, DC: Department of Energy, September 2016), https://energy.gov/seab/downloads/final-report-task-force-future-nuclear-power.

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