THIRD WAY

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The Nuclear Energy Futures Conversations: Injecting Fresh Ideas on Market Opportunities for Nuclear

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The advent of nuclear energy in the 1960's was followed by soaring growth and boundless potential for state-of-the-art reactor technologies. Unfortunately, the real limitations of first generation nuclear technology could not keep up with changing markets and changing public opinion. The exuberance for nuclear technology diminished, and the nuclear industry drifted into an echo chamber. Nuclear technologists insulated themselves from new ideas to improve the technology or to address challenges that could arise down the road. This stagnant thinking brought innovation to a halt and left the industry struggling to adapt as the world evolved around it.

Thankfully, many segments of the industry have decided to step outside the echo chamber and think critically about the next generation of nuclear reactors. But will this community continue to challenge itself? I go to a lot of brainstorming sessions on the future of advanced reactors, and regularly notice that nearly everyone in attendance is a nuclear energy professional, and pretty

much everyone shares a similar set of viewpoints on the technology. Comfort and reassurance of like-minded people is a strong force that can stifle creativity. So how do you make sure an industry that just stepped out of its old echo chamber doesn't walk right into a new one?

One idea we're trying is to push industry leaders out of their comfort zones, exposing them to opinions from a wider universe of experts—including some opinions that run counter to the general consensus of the nuclear community. Along with the University of Wisconsin, Boise State University, and the GAIN Initiative, Third Way created the Nuclear Futures program, a set of workshops that purposefully limits the number of traditional nuclear engineers included in the conversation.

The first Nuclear Futures discussion focused on evolving energy markets and where new nuclear products might be successful. We picked a diverse group of participants with expertise in things like: renewable resource utilization strategies; oil and gas price modeling; data science techniques; fossil and alternative energy technologies; climate change mitigation and adaptation; and economics of the power and transportation sectors. Participants included academics, think tank experts, national laboratory staff, and private sector energy entrepreneurs.

Some were fans of nuclear energy. Some appreciated the clean energy attributes of nuclear but doubted its future given current market structures and the limited number of nuclear products. Some just doubted. But all were interested in joining the conversation. Our discussion coalesced around the themes described below.

Creating a Product the Market Wants

First generation nuclear was established at a time when electricity demand in the U.S. was soaring, when power systems were designed around centralized generation stations, and when electrons were sent across transmission and distribution networks in a one-way flow to customers. In that market environment, it made economic sense to build large (gigawatt-sized) plants which ran continuously and as close to full capacity as possible.

But as one of the workshop keynote speakers—Penn State's Dr. Seth Blumsack—succinctly explains, there's much less need for that traditional role of nuclear power in today's markets. Today's electricity systems and associated markets have become more complex. For instance, as variable sources such as solar and wind have become cheaper and more prevalent, sophisticated market structures and grid controls have evolved to manage their ebbs and flows. Flexibility is increasingly valuable. Power generation is becoming more distributed. New capacity is needed in smaller increments than before. These trends have taken hold in the U.S., and many of them carry over to international markets as well. Unless nuclear technology can adapt to these changes, it's going to have a hard time finding its place in modern energy systems.

Given this context, the workshop experts developed a few guiding rules which could help nuclear developers succeed in this new era:

- **Cut costs by keeping it simple:** Regardless of their non-monetary benefits (enhanced flexibility, scalability, etc.), they'll have a hard time competing in any market if they can't bring down the high capital costs associated with today's designs. The bulk of nuclear's cost comes from long and complex licensing, siting, and construction processes. Innovators must develop simpler supply chains, use efficient manufacturing and construction techniques, and create smaller, simpler designs that don't require as much tailoring for each project site.
- **Swim in more revenue streams:** Today's nuclear makes its profits in electricity and capacity markets. But tomorrow's plants have the potential to offer other valuable products and services. Developers should consider how to take advantage of growing needs for reliable, easily dispatched electricity, off-grid applications, and opportunities to sell carbon-free heat for industrial processes, including in growth markets like desalination.

The Nuclear Community Isn't Paying Enough Attention to Key Technology Advancements

The workshop participants suggested that the nuclear innovation community should be putting more effort toward a number of cutting-edge technologies that could help decrease costs, improve performance, and create new product types. Here are some specific thoughts:

- **Leverage big data and analytics:** Modern machine learning and data analysis techniques, combined with modern sensing, instrumentation, and control, are being developed to get computers to act without being specifically programmed. Web-based language translation and driverless cars are two examples of machine learning approaches. Nuclear should adopt these approaches to understand future energy markets, integrate with other technologies, and provide services beyond electricity and capacity.
- **Modernize manufacturing methods:** Additive manufacturing (also known as 3D printing) of metals could allow for less expensive manufacturing of replacement parts or modular manufacturing. The Company Divergent 3D has printed the Blade, a 700-horsepower, mid-engined 3D printed supercar. Nuclear should be as bold in its vision.
- **Modeling to replace expensive prototypes:** Boeing has dramatically reduced the need for prototype airplanes by developing better computer models. Given the complexity and cost of building even a prototype in the nuclear space, better use of digital modeling and computation-driven insights could be a huge boost for the industry
- **Efficiently locate build sites:** Having to tailor a reactor design to each individual geographic site adds time and expense. By using large existing databases, statistical analysis, and fast computing to identify geographic areas with common site-licensing profiles, nuclear developers could minimize this inefficiency.

- **Modular manufacturing for mass production:** Henry Ford revolutionized his and many other industries with plant assembly techniques. If nuclear can take advantage of mass manufacturing, it will be just as revolutionary.

Innovation in these areas could be greatly aided by private-public partnerships, similar to the strong relationship between defense and civilian technology in American aviation. This synergy has been lost in nuclear, as the Naval Reactors program runs totally disconnected from the power industry.

Grand Challenges and Prizes: New Applications for an Old Idea

Grand challenges and incentive prize competitions—specifically cash prizes for the accomplishment of an engineering achievement that was traditionally seen as impossible—have been used to drive innovation in fields such as aerospace and aviation. One famous example is the Orteig Prize, given to Charles Lindbergh for being the first aviator to fly non-stop from New York City to Paris. This prize was seen as critical in establishing confidence in commercial aviation. So why not attempt to put this successful tool to work for advanced nuclear systems? Third Way recently published the results of a discussion around incentive prizes. Our participants suggested a few other possible prize structures:

- **Critical applications award:** Awarding a winning proposal the right to use federal authority to build three to five advanced reactors at remote military bases, or to power remote communities, such as those in Alaska, that are heavily burdened by costly diesel. The Nuclear Regulatory Commission would need to license the plants with federal money. Developers would need to compete primarily through maximizing the private part of a private-public partnership.
- **Privileged pricing award:** Awarding a project to use federal authority to purchase power at a rate above market price but below the price of today's nuclear power. As with the first suggestion, developers would need to compete primarily through maximizing the private part of a private-public partnership.
- **Cost competitive award:** Awarding a technology that meets a specific production cost for nuclear or that builds a clean energy system that involves nuclear.
- **Integrated technologies prize:** Awarding a new technology that incorporates recent breakthroughs developed in fields other than nuclear.

Timing will be critical for an advanced nuclear prize competition. These are complex projects which will take many years to complete. If any portion of the prize or the costs of the teams competing for the prize is funded with federal money, these long timelines should be clearly communicated to policymakers to set expectations appropriately. Every effort should be made to secure bipartisan support to reduce the chance of the prize competition being derailed by any given election cycle. It

would also be important to structure the prize competition's timeline to ensure the winning products are delivered when markets are ready for them.

Public Investment and Effective Policy in Nuclear Tech: Why It Matters

These conversations are more than just a useful thought exercise. Most participants acknowledged that a strong nuclear sector offers America a number of benefits, not least of which is an insurance policy against market fluctuations and climate change. Maintaining a healthy domestic nuclear infrastructure in the U.S. is also critical to continuing America's influence over international norms regarding nuclear safety and proliferation. Furthermore, public investment in this technology is a particularly effective way to create jobs and boost exports.

The 1960's was an amazing time for the American nuclear industry because it was leading the pack in creating an incredible new technology. Russia, China, India, and Korea are all making commercial nuclear a priority—if the U.S. wants to stay ahead, it will have to do the same. That means crafting sound public policy, careful communications, and extensive community engagement. At our next Nuclear Futures discussion in 2018, we'll discuss how to do exactly that. Stay tuned.

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