THIRD WAY

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What's Missing in U.S. Nuclear? An Innovation Culture

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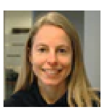

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Takeaways

While nuclear energy is an important part of our low carbon energy mix, it lacks the necessary innovation from a combination of industry, academia, and the national laboratories to optimize its potential.

To encourage private-public partnerships that drive new ideas in nuclear energy technology, the U.S. Department of Energy (DOE) should seed innovation centers, specifically public-private partnerships, which take a fresh look at all the energy production, transmission, and distribution functions of modern society and see where different approaches to nuclear power could make an impact to support a clean energy future. Innovation centers would:

1. Create an environment and expectation where many new ideas are created and examined, a fraction of which would move toward commercialization. As examples, this could broadly include ideas from new reactor designs to new fuels and materials to sensors and controls.

2. Improve the ways we engage and communicate to better demonstrate the value of new nuclear technologies.

These centers would be funded by the DOE through a competitive process, providing funding that ratchets down with time so that innovation centers establish a sustaining private funding base to ensure continuity. Private-public partnerships are desired to help ensure a focus towards commercialization.

The Need for Innovation in Nuclear Technology

The energy sector in the United States is changing. Fundamentally. The challenge of climate change—combined with rising energy demand and issues of water usage, grid stability, cost, and land use—demands rapid and smart decarbonization of our energy system. Some estimates call for a massive 80% reduction in emissions by mid-century. [1] This ambitious and necessary goal requires the deployment and operation of multiple clean energy sources, each bringing specific advantages and limitations to overall energy production, transmission, and distribution. Leading climate organizations, including the International Panel on Climate Change and the International Energy Agency, cite nuclear energy as a key building block in this clean energy future, providing clean, reliable, and affordable power. [2]

But, as much as it's needed, nuclear energy stands at a crossroads. Today, nuclear represents 19% of electricity in the U.S. and 60% of zero-emitting generation. [3] However, many of the current large light water reactors may reach the end of their usable lives by 2035, if not sooner due to premature closures. [4] To adapt, the nuclear community must innovate, expanding beyond the traditional large-scale light water gigawatt reactors to a range of new nuclear technologies of varying size and purpose. This transformation could draw motivation from the information technology revolution. Early on, large mainframe computers were the single source of computational power—taking up entire buildings. But after years of innovation, computers grew far smaller, better, and more personalized. Similarly, nuclear technology must evolve to keep up with changes in the energy sector.

The nuclear sector has traditionally relied on innovation primarily driven by a federal government-led process. This, however, is not how most innovation is achieved in the 21st century. Today technology is developed through the competition of ideas from many companies and institutions, with the federal government at most providing key national test beds and possibly cost sharing of large first-of-a-kind demonstrations. This is beginning to happen in the private nuclear sector, with almost 50 companies and institutions working on nuclear innovation. The federal government now needs to catch up.

In just the past year, the U.S. has taken some significant steps to support nuclear innovation. Most notably, the DOE established the Gateway to Accelerated Innovation in Nuclear (GAIN) program to support the interaction between private and public interests primarily at the development and deployment phases. [5] A recent notable accomplishment was the use permit negotiated between UAMPS and the DOE to provide a pathway for a private small modular reactor—licensed by the Nuclear Regulatory Commission (NRC)—to be built at the DOE site at the Idaho National Laboratory. [6] This is great progress, but additional steps are required to establish a more complete and transformative innovation culture for nuclear technology, a culture that examines not only technology but also the markets for energy products and electricity and innovations in capital project financing. GAIN should be supplemented by a robust early innovation culture that creates innovative concepts to feed into the GAIN institutions. This early innovation culture can be spurred by innovation centers seeded by the DOE. These centers would be funded through a competitive process, providing funding that ratchets down with time so that innovation centers establish a self-sustaining private funding base that ensures continuity.

This paper outlines the features needed to better support the transformation of nuclear technology through innovation and proposes a structure for early innovation centers. These innovations must encompass more than just technical advances. To bring nuclear energy into the 21st century, we must see innovations in the regulatory process, a renewed focus on human capital, and improved engagement with and beyond the broader energy community. To accomplish this we must establish a private-public innovation culture that examines the cost effective functions nuclear power can provide in a clean energy future, how we innovate to provide those functions, and how we modernize communication and public engagement to better demonstrate the value of new nuclear technologies.

Features of a National Nuclear Innovation Program

A national nuclear innovation program should:

- Take a strong guiding signal from studies of probable energy futures and trends in private investment;
- Support an environment that encourages many innovative ideas, knowing many will not make it to commercialization (encouraging many shots on goals), funneling them through a selective process that focuses on the ones most likely to succeed;

- Concentrate more on deploying solutions rather than solely building tools to eventually solve problems;
- Make test beds available for innovators to assess innovation that requires specialized facilities or large, capital-intensive demonstration facilities;
- Allow nuclear developers to have frequent communication with the regulator, so that regulatory signals coincide with the technology readiness of a concept;
- Improve communication and engagement with the broader energy community to reset the conversation about nuclear power; and
- Bring the nation's best students and young professionals into Innovation Centers that support the interaction between private and public interest at the early innovation phase.

As mentioned earlier, the GAIN program is working to make the national test beds and deployment sites available to innovators. This necessitates vigorous research programs at the national laboratories to keep the capabilities and staff world class. The NRC has recently made a number of public presentations describing how they believe they could use their processes more effectively to provide analysis of advanced concepts as the technology develops. This is a strong regulatory step that should be further refined and practiced. GAIN and the NRC discussions are both positive steps that should be supplemented by public-private innovation centers that become a significant creation point for new ideas needed to make GAIN a continuous pathway for innovation through the 21st Century.

Innovation Centers

An optimal research paradigm would support the engagement of private and public enterprises at the early innovation phase, especially if these enterprises recognize the importance of, and engage, a vibrant investment community. While the DOE nuclear energy programs do provide competitive grant or funding programs open to private-public partnerships, these could be enhanced by the creation of innovation centers, incubated with federal funding. These centers could support the following:

Developing new technologies by:

- Focusing on a particular technology theme or on a subset of separate interdisciplinary research areas;
- Aggressively analyzing ideas to select the most promising for development and move them rapidly into the GAIN initiative or other national initiatives, such as those supported by ARPA-E;
- Investigating innovative collaborative research and funding models (e.g., crowdsourcing); and
- Executing their programs with light Federal oversight once the centers are established.

Engaging the next generation of innovators by:

- Providing an environment for cutting edge innovation in nuclear energy that includes a broad representation of skill sets such as engineers, architects, physicists, economists, sociologists, psychologists, artists, chemists, and ecologists;
- Establishing a funding base partially-independent from the federal programs;
- Providing inter-institutional staff rotations that encourage risk taking (e.g., providing a landing place for risk takers); and
- Housing permanent staff with a technical expertise base that supports the innovation culture. Ideas to drive innovation (e.g., term limited project managers as practiced by DARPA) should be investigated.

Resetting the national conversation on the value of nuclear technology by:

- Working to shift the broader cultural conversation around nuclear energy. Key components of this would be a strong public outreach program and a clear dedication to fostering an inclusive culture that is consistent with the diversity of the incoming nuclear workforce and society at large;

- Establishing pathways for entrepreneurial mentors and a local active investment community; and

- Establishing an active national leadership role through fellowships, workshops, staff rotations, and other models.

Depending on the goals of the center leadership, the centers could combine elements of existing federal R&D multi-partner programs such as DOE Hubs, DOE Energy Frontier Research Centers, the National Science Foundation Materials Research Science and Engineering Centers, DOE User facilities, or DARPA/ARPA-E to achieve:

- Industry and financing engagement and impact

- Multi-institution interdisciplinary partnerships

- Permanent technical support staff

- Access through proposal

- Aggressive down-selection process with limited-term project managers and multiple funding modalities including competitions

- Centers of excellence, possibly, but not necessarily, regionally based

These centers would be logically nucleated with funding placed within the Nuclear Energy Enabling Technologies portion of the Office of Energy budget where the DOE Nuclear Energy competed programs are currently housed. Innovations that are worthy of further development within the federal budget could than be moved into the advanced reactor and fuel cycle programs. Alternatively, the innovations could be taken solely into the private sector or as partnerships. The development of the NuScale SMR is a solid precedent for this type of innovation pathway. That project was nucleated in the original Nuclear Energy Research Initiative program that encouraged early innovation through competitive grants that were open to partnerships between academia, industry, and the national laboratories. It is now on a pathway towards deployment.

The Centers could be funded at a level consistent with those currently seen in the DOE Nuclear Energy University Program or the DOE Basic Energy Sciences Energy Frontier Research Centers, ranging from $1M-$4M per year in federal funding. They could be established for three-year initial grants with possible renewal but with an expectation of decreasing federal funding and an increase in private partnerships over time. Federal oversight then becomes a process that encourages innovation with aggressive down-selection rather than top-down goal setting. This could refocus the abilities of the university system toward innovation more than they are currently asked to do. Finally, while this paper focuses on early innovation, similar discipline is required for making decisions as technology moves from development to demonstration.

Conclusions

Nuclear energy is a critical part of the United States' low carbon future. But to maintain it as a resource, let alone expand its use to help displace fossil fuels, a broader innovation culture must be developed in the U.S. nuclear sector. This is beginning to happen with the emergence of nuclear start-ups and advanced nuclear innovation at large companies and institutions, but it can be accelerated through the private-public partnerships at Department of Energy seeded innovation centers.

Innovation centers, funded through a competitive process that ratchets down with time so that a sustained private funding base is established, will broaden the number of ideas that could transform nuclear technology. The private-public partnerships will also provide for a more aggressive down selection of ideas for development.

Following the recommendations described would help transform nuclear innovation in the United States and globally. This requires the creation of a public-private innovation culture that can figure out what functions nuclear energy can provide in this brave new energy landscape, how we innovate to provide those functions – as well as how we engage and communicate to better demonstrate the value of new nuclear technology.

Nuclear innovation is on the right track, but more can be done. The creation of innovation centers is the next step needed to accelerate the pace of nuclear innovation in the U.S. so that nuclear power remains a vibrant part of the national and global energy mix.

END NOTES

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