Young Carla

A Prequel to “A Step-by-Step Guide to Nuclear Innovation Policy.”

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Remember Carla?

In 2016, Erin Burns and Todd Allen introduced Carla, a fictitious graduate nuclear engineer with an idea for a new type of nuclear energy technology, and explained how well-crafted policies could improve government partnerships to assist Carla in taking her idea to commercial demonstration. Six years later, how far have we come in establishing an environment that would create and support a young innovator like Carla? Do we have a set of operating principles that drives innovation and deployment of new ideas, or that supports the emergence and professional advancement of many Carlas?

Many of Burns and Allen’s proposals for Carla have entered into effect. Congress enacted legislation to encourage licensing modernization (the Nuclear Energy Innovation and Modernization Act) and update national research capabilities (Nuclear Energy Innovation Capabilities Act), and has significantly increased funding for nuclear energy programs. The Department of Energy (DOE) established the Gateway for Accelerated Innovation in Nuclear (GAIN), the National Reactor Innovation Center (NRIC), and the Advanced Reactor Demonstration Program (ARDP), aimed respectively at providing access to national nuclear facilities and experts, supporting demonstrations, and public-private cost-sharing. The U.S. now has over 64 advanced reactor companies at various stages of development—the largest number anywhere in the world and at any time in the history of the nuclear sector. These companies are

setting the stage for the development and adoption of new nuclear energy technologies to play a potentially pivotal role in the clean energy transition.

Like Luke Skywalker in Star Wars, Carla has a prequel. When Carla was introduced, the assumption was that she had developed an idea and was ready to move towards commercialization. But how can we create an environment in which more people want to be—and are able to be—like Carla?

Encouraging Carlas

From where would a young innovator draw support and inspiration for a career in nuclear energy–

- National research infrastructure?
- The ability to propose and test new ideas quickly?
- The ability to examine not only technical ideas, but the associated societal, environmental, and economic implications?
- Private-public partnership opportunities?

How would the early-stage work of such innovators be supported?

How could we help future technology leaders in these areas?

Let's take a look.

Infrastructure

Discussions of national infrastructure typically focus on major physical infrastructure like test reactors. But physical infrastructure alone is not enough to incentivize and support a multitude of young innovators. Infrastructure also includes well-maintained and easily accessible codes and data, such as Monte Carlo codes for nuclear transport and nuclear cross-section data. We need structured processes to ensure we update and transfer this important information across generations of workers well into the future.

Infrastructure also includes the programs and processes that facilitate workforce development. We need educational infrastructures that incentivize future Carlas to envision a creative and equitable future and move rapidly toward that future unshackled by a history that defines approaches to nuclear energy through a very narrow, technology-centric lens.

Codes, data, and people are all as critical as testing facilities; they should be updated regularly and made accessible to future innovators.

The Carla Principles of Infrastructure

- Define infrastructure to include not just physical infrastructure, but also codes, data, and human resource development.
- Ensure critical infrastructure is easily accessible to upcoming innovators and designers from all regions and backgrounds.
- Pass critical information from senior to junior people.
- Make decisions about infrastructure updates with significant input from the scientists, engineers, and entrepreneurs that use them—not just from the host institution.

Early-Stage Research

We can encourage many more Carlas by stimulating their imagination and then letting them be daring. We can foster this innovative thinking by encouraging early-stage research that pushes the envelope but which might not yield near-term results. Such research can drive decades of innovation; it has enabled us to reach later stages of development for advanced fission reactors and contributed toward recent breakthroughs in the development of commercially viable fusion power.

Early-stage research should allow the maximum intellectual freedom for researchers and continue based on success of the research, not predetermined time frames. Carlas need a broad range of skills, so we should incentivize a breadth of multi-disciplinary thinking that explores new technological approaches, the role of community engagement in the technology development process, the importance of system integration, and the impact of the cost of new technologies on their successful development and deployment. Early-stage research is typically the way we train new researchers, and support for this research should reflect the time it takes to attain a degree.

The Carla Principles of Early-Stage Research

- Define flexible early-stage research goals in response to long-term national challenges. Overly prescriptive programmatic task descriptions in calls for proposals do not lead to daring research.
- Make decisions to end or proceed with projects based on progress and excellence. Only some early-stage research ideas will be good enough to continue.

- Design academic research structures with student degree pathways in mind.

Research Funding Timing

Securing research funding through peer-reviewed programs takes significant time and resources. Lead times for securing research funding through programs in the DOE's Office of Nuclear Energy typically exceed 12 months, even for the most successful proposals. We should identify and improve the aspects of the nuclear research funding system that drive uncertainty and slow the funding process by complementing the current competitive funding system with a value proposition-based approach. The current competitive approach requires applications to be periodically submitted, comparatively assessed, and distributionally funded. This approach is a subjective assessment of the "best" proposals based on their alignment with a program or political interests at the time, rather than on alignment with long-term strategic objectives.

A value proposition funding approach, on the other hand, is akin to securing a bank loan based on the merits of a business plan. Similar to a bank loan, Carla could submit her applications on a rolling basis, just as loan seekers can submit applications anytime to a bank. Decisions about whether to fund Carla's research would be based on the merits of her proposal and her strengths as a researcher. She would not be required to compete with more experienced and recognized scholars, who are more likely to secure available funding based on reputation and experience. This approach would foster a more collaborative, rather than competitive, research community.

The Carla Principles of Research Funding Timing

- Create additional non-competitive funding pathways that are based on the merits of an application and the strengths of the applicant. These pathways would complement the existing competitive funding pathways.
- State all eligibility criteria of funding opportunities upfront to improve the speed and certainty associated with funding. These criteria may include credentials, required strength of proposal, cost, expected duration, and eventual utilization.

Research Portfolio Design

A well-designed research portfolio moves ideas from discovery through deployment in a structured manner. There should be processes for deciding which ideas merit additional

funding and attention. Ideas that cease progressing should be terminated or scaled back. The pipeline of ideas should always be full and refreshed.

The Carla Principles of Research Portfolio Design

- Design research and development programs thoughtfully so that ideas flow from early discovery all the way through deployment with structured processes for determining which ideas advance through the pipeline.

Private-Public Research Interfaces

Carla may find work with a startup that has minimal connections and relationships within the research community, making it difficult to collaborate with public research entities.

The private sector is often in the position of further developing and commercializing research outcomes from the public sector in the form of developed products and services. However, various issues limit the effectiveness of the interfaces between public and private entities, such as intellectual property protection and the pace of activities, where commercial (especially startup) development and deployment tend to run on faster time schedules than publicly funded research programs. Private programs will absorb research successes as appropriate but do not “wait” for public research success before moving forward. The interface between private and public research should be more cohesive and harmonious to ensure that the research community is engaging in worthy research that will lead to improving the usefulness of nuclear technology.

The Carla Principles of Public-Private Interfaces

- Fund reputable commercial institutions that have demonstrated their capabilities, as well as emerging companies on the frontiers of innovation to support their inherent speed. Funders should acknowledge that private companies will lead innovation on commercial technology applications. Tax-related mechanisms such as the current Small Business Payroll Tax Credit for Increasing Research Activities can further support private research. Other mechanisms to provide rapid funding to innovative ideas may include subsidies and non-cycle-based applications.

- Trade and advocacy groups, such as the Nuclear Energy Institute and the Electric Power Research Institute, should further support gathering, aggregating, and disseminating industry research needs with the broader research community.

Connecting Carla with Communities

One of the main purposes of engineering is to identify and solve practical, real-world problems. Deployment of new nuclear energy technologies requires a product that meets a societal need, achieves regulatory approval, and can be affordably deployed within a reasonable timeframe. Just as important is for these new technologies to fulfill the needs of communities.

Nuclear researchers and developers should obtain community input from the earliest stages of technology design through deployment. This local engagement is especially important in light of historic inequities—displacements of Indigenous populations, the siting of fuel cycle and waste facilities predominantly in communities of color, and health impacts on these communities—created by the development and use of nuclear energy. The entrenchment of these inequities has contributed toward a loss of trust in the nuclear sector.

Principles of equity and environmental justice must be emphasized in nuclear technology design and development. The imminent deployment of advanced nuclear power is an opportunity to advance justice, in part by including local communities in the economic opportunities created by nuclear infrastructure, involving communities in the decision-making process about whether and how to site nuclear plants, and providing power to remote and underserved communities. The nuclear sector, led by the DOE, must work toward repairing the historic inequities created by the nuclear sector. The research portfolio it funds should support both new ideas and the development of people with expertise that intersects technology, economics, policy, and community engagement.

The Carla Principles of Community Engagement

- The nuclear sector must build relationships and mechanisms of trust for ongoing engagement with communities. These relationships and processes should start at the earliest stages of technology design and development in order to increase the odds that these technologies might truly meet people's needs and preferences.
- Perform nuclear research, development, demonstration, and deployment with technology functions, cost, safeguards, community engagement, and policy implications in mind.

Who is Carla?

For several decades starting in the mid-1950s, nuclear reactors were designed by large companies in the US and other places around the world. The designers who led this reactor design work imagined and framed design problems, and made strategic decisions about the mission and purpose of reactors were primarily Caucasian men who rose through the ranks of these companies to positions of leadership. This relative dominance spans many sectors of the economy and in STEM fields.

With the emergence of nuclear energy startups, nuclear reactor designers are now a younger, more vibrant group, but they are still predominantly white and male. Investors fund women and people of color significantly less, resulting in a lack of diversity in nuclear research and researchers.

At a time of unprecedented change in our sector, the nuclear sector should not only revisit our technologies but also reconfigure who has a seat at the table in designing them. The absence of diverse perspectives in the technology design and development process leads to technologies that are not only inequitably designed but also prone to failure.

Many women and students of color describe their professional progression through engineering academia and workforce as a hostile obstacle course, which often leads them to shift careers and leave the discipline or sector. The nuclear sector must work towards making its academic and professional spaces more welcoming. Without such measures, many Carlas with bold ideas may not find opportunities for professional development and for transforming those bold ideas into reality.

The Carla Principles of Building a Diverse Nuclear Workforce

- The challenges in developing and deploying new technologies include technical, economic, and social challenges and educational opportunities such as the Nuclear Engineering Bootcamp need to be expanded, with a corresponding attraction of a wide range of skill sets and ideas.
- Design nuclear engineering university programs to support research and mentorship opportunities for high school as well as undergraduate students from underrepresented backgrounds to support the professional development of these students and create pipelines to nuclear engineering programs at the undergraduate and graduate levels.
- Encourage private investors and DOE to institute community research and innovation grants to encourage citizen science and entrepreneurship for identifying

and solving problems that may be of particular interest to communities transitioning to low-carbon energy. These funds should be disbursed through regional community-university hubs which enable community-university partnerships and give communities access to research expertise and infrastructure around them. Such measures will support the emergence of Carlas from energy facility host communities.