THIRD WAY

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Reorganizing the Office of Nuclear Energy

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Takeaways

- The shift from light water reactors developed by the federal government and built by large utilities to the many new advanced reactor technologies developed by start-ups and universities requires a new business model.
- At the end of last year, the Office of Nuclear Energy (NE) reorganized its management structure in recognition of the shifting needs of America's nuclear industry.
- This reorganization was a step in the right direction, but to fully capitalize on all of the clean energy, economic, and security advantages of advanced nuclear, this reorganization must extend beyond NE's management and into its actual program organization.

- Congress is in the best position to spearhead this multi-year programmatic reorganization through the appropriations process.

Since its creation, the Office of Nuclear Energy (NE) has been organized around the mission of meeting America's growing energy demand with a domestic power source. The large light-water reactors (LWRs) pursued by the program provide incredibly reliable electricity in enormous quantities. However, demand for power in the U.S. has been relatively flat for the last 15 years. [1] So we don't need lots and lots of megawatts. What we need today is lots and lots of energy products to do lots and lots of different things.

We need reactors that can provide flexible generation alongside variable renewables. We need reactors that can be packaged and shipped around the world—including to developing nations that need baseload generation to industrialize, but lack their own nuclear supply chain. We need clean sources of heat to decarbonize industrial processes. We need small, affordable sources of energy to power remote communities who today rely on expensive and dirty diesel fuel. [2]

If the U.S. develops even a few of these various reactor technologies, we can contribute heavily to the fight against climate change, boost domestic manufacturing and exports, and reinforce America's influence in global affairs. Given these huge rewards and the changing global market, NE's scientists and experts have already shifted from working on LWRs to advanced technology. But while they've changed *what* they work on, NE hasn't fully changed *how* they work. Developing and deploying a new generation of reactors will require unique methods that differ from NE's efforts on LWRs.

Some of this is due to technological difference. Another distinction, though, is *who* is developing advanced reactors.

Traditionally, very large utilities and technology companies are the ones building LWRs. They have the money and staff to navigate complicated bureaucracy. In contrast, many of the most promising advanced reactor companies are small start-ups with minimal staff and tight budgets. They're working on a Silicon Valley model – good for innovation, but bad for figuring out the inner workings of federal agencies.

NE is facing changes in global markets, a slate of new reactor technologies, and a different kind of private sector partner than it's used to working with. To maximize its efforts and create the same level of success it generated with LWRs, NE must adapt to modern conditions.

Getting started with a modernized management structure

At the end of 2016, NE reorganized its management structure to respond to a growing and diversified set of private sector innovators. This reorganization reflects DOE's new commitment to support these entrepreneurs and to rapidly commercialize advanced nuclear reactors—a big step in the right direction

The old structure had two major and often interrelated problems that kept NE from meeting its full potential. First, it failed to provide a clear pathway from early innovation to commercialization. Let's say you're the COO of a small advanced nuclear project and you want to find out what resources DOE can provide. You know you're at a technology readiness level (TRL) of 3. Do you go to the Office of Advanced Reactor Technologies? Or the Office of Innovative Nuclear Research, considering you're at a relatively early stage of development? What if you're using a unique type of fuel, do you then go to the Office of Fuel Cycle Research and Development? Not having NE organized around a commercialization pathway prevents innovators from knowing where to go for help.

Technology Readiness Levels (TRLs) are a standardized way to gauge how close to commercializing a given technology is. The DOE has an existing energy technology TRL that they already use. This could be a helpful and intuitive way for advanced reactor developers to find the right programs, services, and expertise they need from NE. TRL should not, however, be the driving factor in whether and to what degree NE provides funding and other support to a commercial vendor.
TRL 1: Basic principles observed and reported
TRL 2: Technology concept and/or application formulated
TRL 3: Analytical and experimental critical function and/or characteristic proof of concept
TRL 4: Component and/or system validation in laboratory environment
TRL 5: Laboratory scale, similar system validation in relevant environment
TRL 6: Engineering/pilot-scale, similar (prototypical) system validation in relevant environment.
TRL 7: Full-scale, similar (prototypical) system demonstrated in relevant environment
TRL 8: Actual system completed and qualified through test and demonstration
TRL 9: Actual system operated over the full range of expected mission conditions

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It also means that your hypothetical project may have to go to all three offices for different pieces of what you need, eating up your limited time and money, which gets to the second problem: the old structure inhibited communication with private industry and coordination between programs.

Programs within three different Offices may all be working on separate sets of issues impacting projects at TRL 3 and you would need to find and contact each. Finding one may not lead to the others—these programs may not be coordinating with one another, as they're under separate leadership. That not only makes it more difficult for innovators, but this lack of communication can also result in duplicative efforts and wasted resources.

Luckily, NE leadership recognized the need to make its management structure more accessible and better coordinated. Now, there's an office of Accelerated Innovation in Nuclear for activities lower on the TRL scale all the way to an Office of Advanced Reactor Deployment, for, well, deployment-related activities at the end of the TRL scale. This reorganization not only makes it easier for innovators to know where to go for help, but it also builds in better communication between programs working on similar problems.

NE deserves major credit for seeing this changing landscape, identifying the opportunities for advanced nuclear, and taking initial steps to help America seize those opportunities. What's needed now is a reorganized program structure that will allow NE to achieve the goals it set out in its new management structure.

Wait, what's the difference between "management structure" and "program structure"?

This is where things get a bit wonky. Management structure refers to how NE's offices are organized and how its leaders in the Forrestal Building communicate with one another. Basically, who has responsibility for what. Program structure, on the other hand, is what you see in the individual program budget lines when going through the appropriations process. The budget lines aren't just how the money gets divvied up—it represents and dictates the work and goals of individual programs as well as how they relate to one another. For example, while the management restructure now includes an office of advanced reactor deployment, there's no corresponding budget line and, therefore, no corresponding deployment program.

In essence, program structure dictates the actual work being done to achieve NE's goals. The *management* structure at NE was updated at the end of 2016. Its *program* structure must now be updated.

Reorganizing its management was simple enough for NE to do on its own. Adjusting programs will be a slightly more complex undertaking. NE theoretically could get this next stage of the process started by suggesting programmatic restructuring in their FY2018 budget request. But given the confusion and chaos of the White House transition process, it's entirely possible that even a logical and productive budgetary adjustment will be lost in the shuffle as the Department hustles to finalize its request. And at the end of the day, DOE will submit just that—a request. Congress has the final say in the matter, and is in the best position to spearhead this reorganization.

NE is on the right track, but needs to complete its

programmatic reorganization

In addition to the management reorganization, NE has also made some specific programmatic additions that have already been helping the burgeoning advanced reactor industry meet critical milestones—and which illustrate NE's recognition that programmatic changes are needed. The GAIN initiative, launched in November 2015, the Small Modular Reactor (SMR) Licensing and Technical Support program, the new nuclear initiative at Cyclotron Road, the small business voucher program, the cooperative R&D program, Chain Reaction, and the Nuclear Innovation Bootcamp are all great examples of NE's recognition of and adaptation to the changing needs of nuclear innovators. These new efforts are a step in the right direction, placing a clear emphasis on commercialization of advanced reactors.

But the commercialization mission hasn't fully permeated the rest of NE's work, and NE's program structure is not conducive to getting technologies from concept to market.

While the management structure is now more clearly organized around advanced nuclear commercialization, the program structure still has many of the problems of the old management structure. One of the biggest problems is a lack of communication with industry; ideally, NE would be talking to advanced companies regularly to understand what common problems they are facing. Solving these common challenges—whether it's a material that can resist corrosion from salt or a new type of highly-efficient fuel—should be a top priority for NE. Instead, today, decisions on where to allocate funds are sometimes dictated by what lab or university researchers want to work on and not what industry most needs. Sometimes this overlaps with what industry needs, sometimes it ends up with tools no one will ever use outside of a lab.

There's also lack of communication between programs that leads to redundancies. So, NE may be funding a university to develop a new material, but they may also be funding the

same work at a lab or a separate university. We desperately need a well-funded and scaled-up NE, and especially in today's current budget environment where a large increase may take longer than usual, we need to ensure we're using funds as efficiently as possible. With better organization and communications, NE could better use limited resources.

The absence of a clear commercialization mission also results in projects being ended when they should continue and projects continuing when they should end. For example, university programs end after three years, without an evaluation of whether the work should be continued, and programs for developing radiation resistant materials and fuel development programs, both multi-year endeavors, start and stop. Without a specific end goal driving NE work, decisions about project lifespans are made based on other factors—a university contract ran out of time, or a lab researcher heading a project left for another job. Those aren't reasons to stop good work.

It's time for an update that puts programs more in line with the new management structure.

NE's program structure should follow the logical phases of commercialization

To be more successful in commercializing technologies, NE must structure its program to reflect the way that technology progress actually happens. Technologies moving towards commercialization don't bounce back and forth in terms of their level of readiness or the type of support that they need —so nuclear innovators shouldn't have to bounce back and forth between NE programs as they currently do. Instead, NE's programs should mirror the four chronological phases of commercialization, with each phase presenting its own unique challenges and requiring its own unique solutions:

1. **Innovation:** conducting basic research and determining the feasibility of an idea;

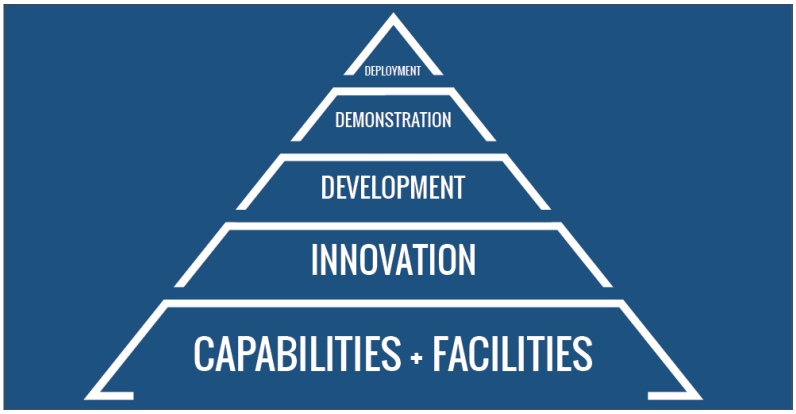
2. **Development:** proving performance at scale and in a realistic environment in a test laboratory;

3. **Demonstration**: proving performance of a first-of-a-kind design at scale over a full range of operating conditions;

4. **Deployment:** building a reactor and initiating commercial operations.

From communications to energy to medicine—public funding during all four of these stages has been a critical element in getting new technology from idea to commercial product. Advanced nuclear energy is no different. NE needs to develop a portfolio of support mechanisms appropriate for each phase.

These phases can also be thought of as a triangle, all built on a base of infrastructure capabilities and facilities.



As projects—either full reactor concepts or individual components—advance through each phase, the private sector should be expected to contribute greater amounts of funding and partnerships may extend for longer periods of time. Structured approaches for deciding when to move ideas up the triangle—and when to terminate funding—need to be established. Essentially, NE should act like a well-informed investor with a portfolio of projects.

Reorganizing NE's program structure around these four phases addresses many of the same problems solved by the management reorganization. Having clear innovation,

development, demonstration, and deployment programs with corresponding TRL information would allow advanced reactor companies to know exactly where in NE they should go for their needs. It would also prevent programs from working on the same issue without coordination. For example, a demonstration phase program and an innovation phase program wouldn't both work on a TRL 2 project. Additionally, there would be increased coordination within each phase, preventing two similar deployment level efforts from moving forward without knowledge of the other, as they would both be overseen by the Office of Advanced Reactor Deployment.

Following these four phases would also improve coordination between NE and other agencies outside of DOE. For instance, it would allow the Nuclear Regulatory Commission (NRC) to estimate the readiness of various technologies so it is better prepared to meet licensing and other regulatory needs when the time comes. Having a defined innovation phase also helps to connect back to Office of Science programs, flagging those areas where fundamental improvements in basic science could dramatically alter nuclear technology trajectories.

In addition to reorganizing around these phases, there are key principles that should be implemented across the triangle. Support across all levels should take energy futures into account, with decisions on which projects are funded and where they fall in the triangle in part determined by the amount of private funding they can bring to the table. NE should work on problems common to many reactor developers at each stage. And It should establish strong research interactions with countries that hope to add nuclear into their energy mix.

How Congress can help NE finish the job

Here's the play-by-play on how to reorganize NE's program structure to match its new management structure and best

serve the needs of the burgeoning advanced reactor industry.

CAPABILITIES & FACILITIES

Moving through the four phases requires a strong base of physical and staffing infrastructure, represented in the triangle by the "Capabilities & Facilities" layer at the bottom. Its function is to maintain critical national research infrastructure—buildings, equipment, and staff at national labs and universities—to support general R&D for existing and advanced nuclear. This is the base of the triangle that enables innovation.

***Reorganization Goals*:**

- Address deferred maintenance issues and establish an ongoing program to keep the national transient testing, fuel development, test reactor capability, and post-irradiation examination capabilities in world class condition;

- Ensure high-quality staff are available to support industry as they use national R&D capabilities like the proposed fast test reactor;

- Increase coordination with the National Scientific User Facility program to provide access to capability as needed by innovators. Work to make Office of Science User Facilities more routinely and easily accessed for nuclear energy development.

***Reorganization Budget Actions*:**

- Increase the FY18 Idaho Facilities Management budget line by 50% over the FY16 level in order to address deferred maintenance and to begin work on the Molten Salt Reactor (MSR) test bed and the fast test reactor;

- Further increase the Idaho Facilities Management budget over the next ten years to complete construction of the MSR test bed and fast test reactor, as well as other infrastructure capabilities;

- Reinforce need recognized in the House-passed and Senate Committee-passed Nuclear Energy Innovation Capabilities Act to determine a pathway to establish domestic fast test reactor capability.

INNOVATION

The goal of the innovation phase is to generate many new ideas, a fraction of which will eventually become commercial products. Here, NE can improve the chance of commercial success by offering early innovation training opportunities like the Nuclear Innovation Bootcamp held at the University of California-Berkeley, incubator support to move ideas into startup companies, small business voucher programs to increase access to national laboratory capabilities, more competitive R&D awards with a focus on commercialization, and a more streamlined national laboratory access with small changes like simplified contracting mechanisms and more predictable intellectual property rights.

***Reorganization Goals*:**

- Support programs that encourage professionals to start companies that innovate in nuclear technology (e.g., Nuclear Bootcamp and incubator support as part of the DOE Lab Embedded Entrepreneurship programs). Increase support for GAIN small business vouchers;

- Run competed solicitations for new ideas, guided by knowledge of systems analysis and the goals of privately funded innovator communities. Use these programs for both domestic and international programs;

- Establish guidelines for how support is allocated at the innovation phase, factoring in the amount of private-sector funding a project can bring to the table, and implement a review process that allows certain projects to graduate to the development phase.

***Reorganization Budget Actions*:**

- FY18 increase of at least 75% over FY16 levels, with potential additional increases over the next five years.

DEVELOPMENT

The function of this phase is to prove that an idea can work in realistic conditions in a test laboratory. The development phase should support advanced reactor technologies that have a higher probability of reaching commercial deployment, whittled down from the projects that participated in NE Innovation programs. To ensure that these projects are worthy of significant development funds, they should be selected using a detailed analysis of key market, regulatory, and technical deployment factors, and should have to prove that they can raise a certain level of private funding.

***Reorganization Goals*:**

- Allow for larger value GAIN vouchers, cost shared reactor development projects, and other private-public approaches;

- Ensure development-phase activities are connected to what's happening at the innovation-phase to move the best ideas up the triangle, as well as maintain the technical expertise required to host the national test bed;

- Establish guidelines for how support is allocated at the development phase, factoring in the amount of private-sector funding a project can bring to the table, and implement a review process that allows certain projects to graduate to the demonstration phase.

***Reorganization Budget Actions*:**

- Gradually increase to 50% over FY16 levels by FY22.

DEMONSTRATION

The function of the demonstration phase is to prove that reactor ideas that worked in the laboratory can work in real-world conditions. Innovators in the demonstration phase

may need licensing support or large, multi-million dollar, cost shared R&D projects.

Reorganization Goals:

- Develop a strategic portfolio of support options that recognizes that innovation companies come in a wide variety of sizes, functions, and demonstration readiness;

- Establish guidelines for how support is allocated at the demonstration phase, factoring in the amount of private-sector funding a project can bring to the table, and implement a review process that allows certain projects to graduate to the deployment phase.

Reorganization Budget Actions:

- Expand the existing Small Modular Licensing Technical Support (SMR LTS) program to include LTS for non-light water advanced reactors, plus vital post-LTS assistance for SMRs and, eventually, for non-light water advanced reactors;

- Fully fund SMR LTS at $95 million for FY18, with increases as the program expands;

DEPLOYMENT

This phase supports advanced concepts that have graduated from the demonstration phase, as well as technologies that have already reached commercialization, like light water reactors and used fuel disposition technologies. During this phase, NE could provide commercialization support like power purchase agreements (PPAs) and loan guarantees, as well as provide guidance on the benefits of mechanisms such as production tax credits (PTCs) and investment tax credits (ITCs). Additionally, DOE could use its resources at the national laboratories and universities to help countries with no nuclear history build-up workforce infrastructure they'll need before they can purchase U.S. products.

Reorganization Goals:

- Expand the current light water reactor (LWR) sustainability program to take a forward look at needed research for plants just coming on line like SMRs;
- Provide the best science and technology for national used fuel programs.

***Reorganization Budget Actions*:**

- Evaluate existing PPA and loan guarantee efforts and programs to determine if any changes need to be made to allow advanced reactors to participate;
- Provide guidance to Congress on the best deployment level support for advanced reactors, including production tax credits, investment tax credits, loan guarantees, or other to-be-determined mechanisms;
- Five-year increase of 90% over FY16 levels for the current light water reactor sustainability and used fuel programs.

PROGRAM GUIDANCE

Program Guidance isn't a slice of the triangle. It runs alongside instead, providing needed support and direction that spans every level of the process. This includes systems analysis to guide program development and execution, international cost-sharing and R&D agreements, and overall program oversight.

***Reorganization Goals*:**

- Establish a systems analysis group that provides guidance to capabilities development, innovation programs, deployment programs, and deployment support functions;
- Improve strategic use of international research collaborations;
- Provide program oversight in a manner that encourages idea flow from innovation to deployment with strong focus on commercialization.

***Reorganization Actions*:**

- Establish a new systems analysis function at $10M per year;
- Increase international programs budget by 67% over FY16 levels.

Conclusion

The emerging advanced nuclear industry represents a radical shift in technology and business model. In the past few years, NE has recognized this shift and has begun to change how it works to better serve these innovators – from new initiatives like GAIN to including nuclear at the traditionally renewables-focused incubator Cyclotron Road. They even began to shift how the Office is organized and completed their management reorganization at the end of last year. Now, it's time for Congress to help NE finish the job, complete its programmatic reorganization, and ensure that the U.S. doesn't miss out on the climate, economic, and foreign policy benefits of the advanced reactor industry.

END NOTES

1. U.S. Energy Information Agency, "Electricity Net Generation: Electric Power Sector," Chart, *Monthly Energy* Review, March 2017. Accessed on April 4, 2017. Available at: http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_6.pdf.

2. Josh Freed, Samuel Brinton, Erin Burns, and Amber Robson, "Advanced Nuclear 101", Report, Third Way, December 1, 2015. Accessed on April 4, 2017. Available at: http://www.thirdway.org/report/advanced-nuclear-101.