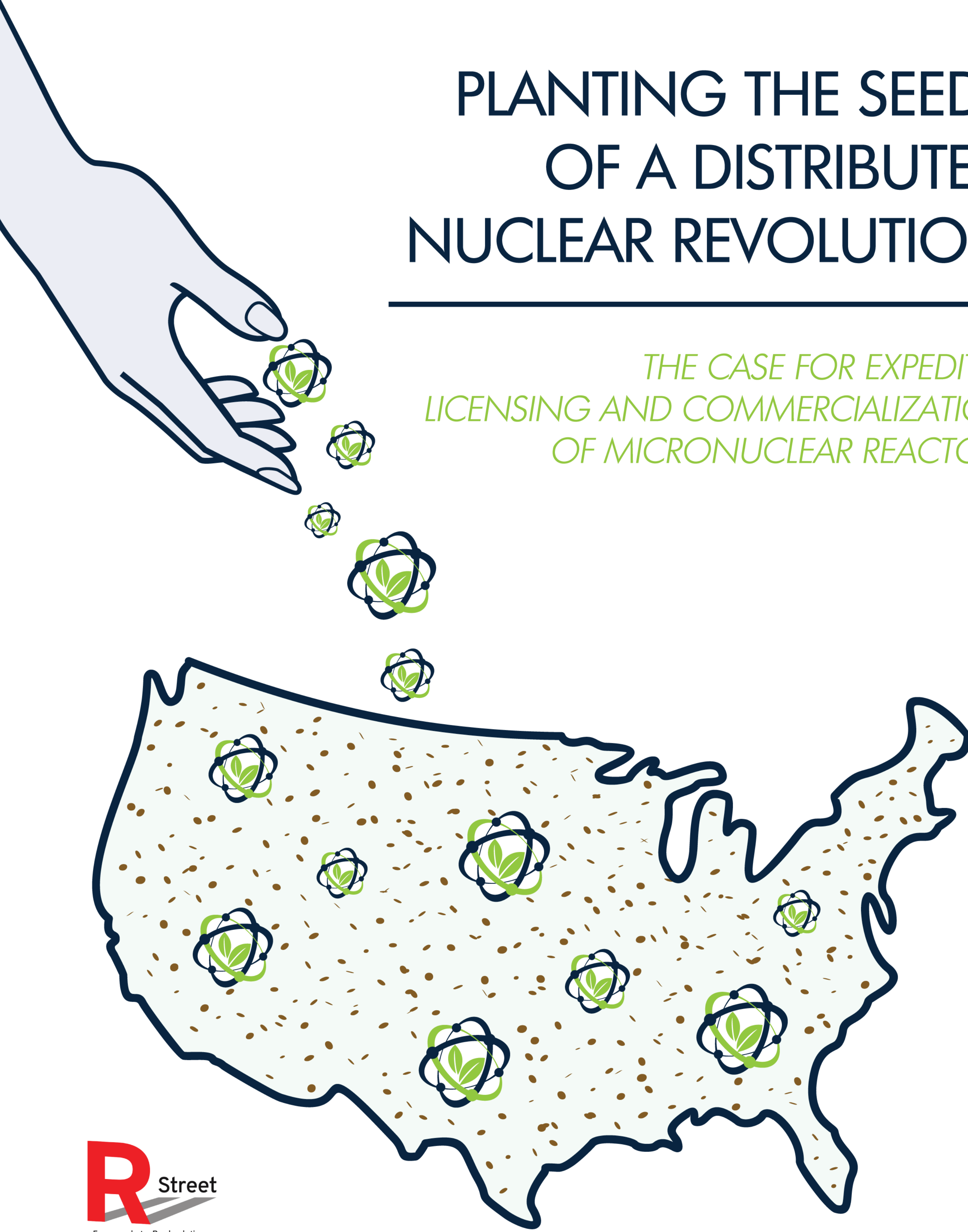
PLANTING THE SEEDS OF A DISTRIBUTED NUCLEAR REVOLUTION

THE CASE FOR EXPEDITED LICENSING AND COMMERCIALIZATION OF MICRONUCLEAR REACTORS



R Street
Free markets. Real solutions.

CLEARPATH

BREAKTHROUGH INSTITUTE

JESSICA LOVERING, WILLIAM MURRAY, JOSIAH NEELEY, SPENCER NELSON, TED NORDHAUS

PLANTING THE SEEDS OF A DISTRIBUTED NUCLEAR REVOLUTION

THE CASE FOR EXPEDITED LICENSING AND COMMERCIALIZATION OF MICRONUCLEAR REACTORS

R Street
Free markets. Real solutions.

CLEARPATH

BREAKTHROUGH INSTITUTE

TABLE OF CONTENTS

Introduction

In the United States, slow demand growth, market liberalization, and competition from natural gas and renewables have dimmed the prospects of building new, large, light-water nuclear reactors. The supply chains and skilled labor force necessary to build new plants have atrophied over the three decade hiatus in domestic construction — despite two reactors under construction in Georgia — meaning that virtually any new nuclear build is essentially a first-of-a-kind reactor. While multiple builds, standardized design, and public finance are proven pathways to low cost nuclear energy, the United States presently has neither the economic demand nor the institutional arrangements that would support multiple large reactor builds and result in the associated technological learning.

For these reasons, reestablishing an economically competitive domestic nuclear industry in the United States will require a different path, one that is responsive to current economic, political, and institutional realities and can leverage America's comparative advantage: our unrivaled innovation system and entrepreneurial business culture. Small and microreactors offer just such a possibility — relying upon economies of multiples rather than economies of scale and allowing standardization without the implicit nationalization of the US power sector that any strategy for learning through standardization of large reactors would require.

Microreactors bring several other advantages as well. Small reactors allow safe operation with radically simplified designs, making the case for far reaching licensing and regulatory reform much stronger. There are a range of niche markets — including off-grid and industrial — that they might immediately compete for without having to compete with mature generation technologies in wholesale electricity markets. As one of the greatest challenges facing advanced reactor development has been the lack of recent construction experience, initial deployment of small- and micro-reactors could also bolster confidence in larger designs.

Further, given the reality that virtually any first-of-a-kind reactor today will require some public support to commercialize, microreactors offer the opportunity to avoid top-down down selection by public officials. At very modest cost to the public treasury, the federal government could jump-start an advanced nuclear industry in which multiple designs from multiple companies would compete for public contracts, and the government would choose based on predefined performance metrics. This program could be modeled on NASA's Commercial Orbital Transportation Services program, where NASA launched a globally competitive commercial spaceflight industry by radically rethinking how it developed and procured orbital launch vehicles and services.

For these reasons, workshop participants coalesced around a series of policy measures to accelerate deployment pathways starting with the smallest nuclear reactors, microreactors, defined here as reactors smaller than 10 megawatts thermal (MWth). For context, a 10 MWth reactor is about two to three thousandth the size of a typical commercial reactor being built today, and it would have the power to supply electricity for roughly 2,000 households. Notably, microreactors would be smaller than several research reactors operating around the country, and should be licensed with a similar risk-informed process (recognizing the very minimal risks such tiny reactors pose). We also detail three further proposals that would be beneficial to all efforts to develop advanced nuclear reactors, large and small.

Several of our suggestions that follow are also included in the Nuclear Energy Leadership Act (NELA) recently introduced in the US Senate. We consider this bipartisan legislation to be a significant first step in modernizing the nuclear innovation system. Also, the Nuclear Energy Innovation Capabilities Act (NEICA) has passed both the House and Senate, signaling important bipartisan momentum around advanced nuclear policy changes.

1. Alternative Licensing Pathway

While all commercial NRC licenses are currently granted through section 103 of the Atomic Energy Act (AEA), historically many licenses were granted through section 104 to test and demonstrate reactor designs. Section 104 was utilized to encourage innovation and had more flexible standards suitable to initial or one-of-a-kind implementation. Section 104b was originally used for commercial demonstrations, while 104c was and still is used for test and research reactors. An important motivation for licensing reform is the observation that many microreactor designs are smaller than some research reactors operating around the country today.

It may be possible to reinstate 104b regulations to allow for commercial demonstration of microreactors. The AEA currently restricts the use of 104b such that it can only be used when specifically allowed by Congress. The AEC formerly had a reactor demonstration licensing program (104b), which most of the original commercial reactors went through. The 104b pathway was phased-out after a predetermined time period to reflect light-water reactors technological maturity. If 104b was reinstated, it could have a 10MWth limit or only be used for first-of-a-kind reactors. Such a program for microreactors could be modeled on the current 104c process, where the NRC is tasked to:

> "... impose only such minimum amount of regulation of the licensee as the Commission finds will permit the Commission to fulfill its obligations under this Act to promote the common defense and security and to protect the health and safety of the public and will permit the conduct of widespread and diverse research and development."

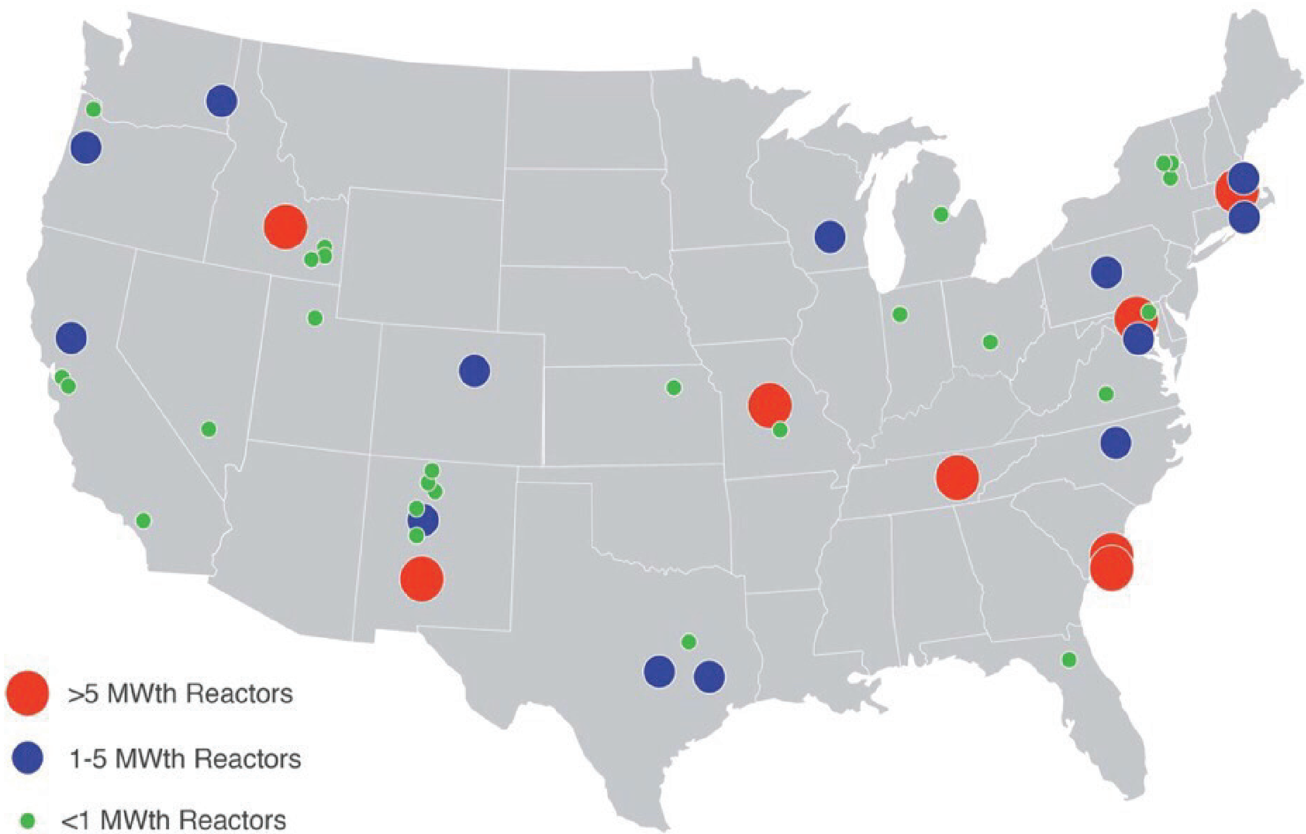
For the other section 104 option, research reactors are still licensed through the 104c process. The only distinction between 104b and 104c (besides the fact that 104c is still in use) is that they cannot generate revenue in excess of 50% of their expenditures. Some have suggested that reactor developers could build commercial demonstrations through the 104c process for research reactors, which allows owners to generate and sell electricity (and other services) as long as they don't recoup more than 50% of their expenditures.[1] It should be possible to convert a 104c license into a 103 license. This may work for some developers, but as there is no safety distinction between commercial and research reactors, this seems like an overly strict limitation on the finances of reactor developers. Developing a similarly modeled process through an NRC "skunk works,"[2] but for commercial microreactors, would recognize the safety realities of such small designs, while also recognizing the financial realities of private reactor developers.

"We consider this bipartisan legislation to be a significant first step in modernizing the nuclear innovation system."

The NRC does have a new process for licensing prototypes under 103 (10 CFR 50.2), but no design has gone through the process yet and it is expected to take a similar length as a full-scale commercial license. We suggest either reinstating the 104b process or allowing reactors under 10MWth to apply through 104c with full cost recovery.

Congress should explore changing the Atomic Energy Act to allow NRC to license microreactors (with full cost recovery) under 104c rules or revive the 104b commercial demonstration licensing pathway for microreactors.

RESEARCH REACTORS AROUND THE U.S.



Industrial Hub reactor concept. Courtesy of Third Way.

If neither of these options is possible, or would take too long, Congress should direct the NRC to create a "skunk works" to fast track regulation and licensing for power reactors under 10 MWe. Due to the complexity of new designs, the NRC has recently shown interest in pursuing this approach through "tiger teams,"[3] and it should be encouraged. Current licensing requirements are designed for large power projects operated by large utilities, and have an artificial barrier between research and commercial reactor projects. While licensing reform is needed on a grander scale, we propose a small-scale solution that could be implemented faster.

The regulatory delineation between research and commercial reactors is not a risk-informed approach to safety. Different licensing regimes based on size, on-site fissile material, or projected off-site release under accident scenarios would all be better, risk-informed policies.

Whether under 104b or 104c requirements, or through a new licensing pathway, NRC needs to create an expedited licensing process for reactors under 10 MWth that want to generate and make a profit selling electricity or other services.

Potential applicants for such a pathway:

- Companies developing microreactors.
- Companies who want to test a small-scale test reactor or prototype first, while generating revenue to cover their full costs.
- Universities who would like to build/convert a research reactor that generates electricity with the option of full cost recovery.

Recommendations for operationalization:

- Have Congress appropriate funding to NRC to change fee-recovery structure to a 50% cost recovery with applicants,[4] mitigating some financial hurdles for smaller firms.
- Develop risk-informed regulatory processes in both reactor licensing and in other divisions such as nuclear materials, safeguards, and security.
- Reform ACRS review during the licensing process to minimize its effect on approval timeline. Congress may need to amend the Atomic Energy Act.
- Provide "categorical exclusion" to NEPA review for reactors under 10 MWth in size.
- Develop a process through which reactor developers can utilize pre-approved sites (well-characterized), such as national labs or existing nuclear power plants, similar to NASA's development of commercial spaceports.
- NRC should hire staff with experience in start-ups, venture capital, or other innovative industries.

2. Federal Power Purchase Agreements (PPA)

Enable federal agencies to sign power purchase agreements (utility service contracts) with nuclear power projects for 40 years, or the life of the plant, and for the contract to be scored annually in federal budget appropriations. Also enable agencies to compensate nuclear plants that supply resilient electricity or other valuable services such as hydrogen production. Possible agencies could be the Department of Energy or the Department of Defense. Congress should also establish a pilot program for utilizing PPAs to procure power from advanced nuclear reactors as part of broader nuclear innovation legislation.

For example, Congress could appropriate funding to subsidize above-market rate PPAs for the first handful of microreactors. As a rough estimate, signing 10-year PPAs with four reactor vendors for their first three builds could cost as little as $2 billion over 10 years, but would allow these companies to gain significant manufacturing and operating experience while providing reliable electricity to federal sites. By providing a contractual commitment to purchase power, government would lower the business risk for the project and thus improve the financial profile of the project for private investors.

As background, NASA's Commercial Orbital Transportation Services program, which sought to stimulate the commercial spaceflight industry through outcome-based rewards, benefited from the fact that NASA could also serve as a customer and purchase launch services from companies that met certain milestones.[5] It is also possible that the combination of carbon-free baseload power, modularity, small land requirements and improved energy security could give federal authorities reasons other than costs to contract with advanced nuclear.

Transit Hub reactor concept. Courtesy of Third Way.

Further measures to support development and commercialization of advanced nuclear reactors.

3. Fast Test Reactor

The Department of Energy should commission a fast test reactor to provide fast neutron testing capabilities to advanced reactor developers, researchers, universities, and the government. This is a cross-cutting need for many in the advanced reactor development community to test fuel and materials. The lack of a US-based fast test reactor is a major bottleneck in the development of non-light-water advanced reactors with many proposed advanced nuclear fuels expected to be integral in the performance of Generation IV reactors. It could also be used by thermal reactor developers who can shorten testing time with the higher neutron flux. Currently, companies need to go to Russia or China for fast neutron testing capabilities.

4. Reform Price-Anderson Act

With Price-Anderson set to expire in 2025, Congress should consider how to modernize the liability limits, shifting from a dollar based cap on operator liability to an exposure based limit reflecting current scientific understanding of radiological risk. One place to start would be for DOE to restart the Low Dose Radiation Research Program. However, actually putting such risk-informed regulations into place would be more complex. The EPA sets the standards for radiological health risks, but FEMA sets guidelines for evacuations, and the NRC's Incident Response Centers activate in the event of a serious accident to coordinate emergency response. One option would be to form an inter-agency committee to review these standards and emergency protocols based on the best available science.

If undertaken with accompanying regulatory reform to reflect true radiological risk, a further step could be to completely privatize nuclear insurance and liability. The process to implement such a radical change would need to be well-thought out, so as not to disrupt the current advanced nuclear industry. But many have noted that the insurance market can handle accidents of similar financial scale as a nuclear power plant meltdown, such as hurricanes and terrorist attacks.[6] Proponents argue that privatization would incentivize the sharing of best practices and effective oversight.

5. High-Assay Low-Enriched Uranium

Many of the advanced reactor design under development today are going to rely on novel fuels. In particular, many will require uranium fuel enriched above the standard 5% commonly used today. Currently, the US does not have a domestic source of such high-assay low-enriched uranium, and this could present a significant roadblock to many developers.[7] It could take up to a decade for a new fuel cycle to be commercially ready,[8] so planning for the infrastructure, regulation, and supply chain must begin now. In the long-term, the US should develop a domestic source of HALEU; in the short-term, the US could create a strategic reserve starting with excess military HEU. The NRC should also move forward with regulation for transporting HALEU and licensing Cat II facilities.

Endnotes

1. Adams, Rod. "Licensing demonstration reactors in the United States." September 8, 2015. https://atomicinsights.com/licensing-demonstration-reactors-in-the-united-states/

2. *Skunk Works was the pseudonym for Lockheed Martin's sub-organization that worked on advanced aircraft, but the term has come to refer to a small, nimble group within a larger organization that has the freedom to pursue innovative and creative projects without the burdens of bureaucracy.*

3. NRC. "Achieving Moder Risk-Informed Regulation" (2018). https://www.nrc.gov/docs/ML1811/ML18110A187.pdf

4. *This is the percentage utilized by the Food and Drug Administration and the Federal Aviation Administration and is a more reasonable division than the current 90% cost recovery required for the NRC.*

5. Lovering, J. "Case Study No. 1 in How to Make Nuclear Innovative" The Breakthrough Institute https://thebreakthrough.org/index.php/issues/nuclear/commercial-spaceflight

6. Tetley, M. "Nuclear Insurance: yesterday, today, tomorrow." Price Forbes & Partners. http://www.aidn-inla.org.ar/wp-content/uploads/2014/10/59-M-TETLEY-Nuclear-Insurance-yesterday-to-day-tomorrow.docx

7. Merrifield, J. Leidich, A. "Advanced Fuels — Looming Crisis in Fueling Advanced and Innovative Nuclear Reactor Technologies." Nuclear Infrastructure Council and Clearpath. February 21, 2018. https://assets.clearpath.org/2018/02/34e01aa863572d11e2a89b592dcbfb56-NIC-Clearpath-High-Assay-WP.pdf

8. Tschiltz, M. "Addressing the Challenges with Establishing the Infrastructure for the frontend of the Fuel Cycle for Advanced Reactors." Nuclear Energy Institute. January 2018. https://www.nrc.gov/docs/ML1810/ML18103A250.pdf

Arctic Village reactor concept. Courtesy of Third Way.

Based on a workshop co-hosted by the Breakthrough Institute and the R Street Institute

About the Authors

JESSICA LOVERING is Energy Director at the Breakthrough Institute.

WILLIAM MURRAY is Federal Energy Policy Manager with the R Street Institute.

JOSIAH NEELEY is Senior Fellow, Energy Policy Director, and Southwest Region Director for the R Street Institute.

SPENCER NELSON is a Policy Associate at ClearPath.

TED NORDHAUS is Founder and Executive Director of the Breakthrough Institute.

About the Organizations

The Breakthrough Institute is a leading global research center that leverages high-quality scholarship to identify practical solutions to major environmental and human development challenges.

R Street Institute is a nonprofit, nonpartisan, public policy research organization that engages in policy research and outreach to promote free markets and limited, effective government.

ClearPath's mission is to develops and advances conservative policies that accelerate clean energy innovation.

Workshop Participants

Kati Austgen, Nuclear Energy Institute
Jeremy Harrell, ClearPath Foundation
Sarah Hunt, Joseph Rainey Center for Public Policy
Josiah Neeley, R Street Institute
Everett Redmond, Nuclear Energy Institute
Joseph Majkut, Niskanen Center
Philip Rossetti, American Action Forum
Caroline Cochran, Oklo Power
Jacob DeWitte, Oklo Power
Katie Tubb, Heritage Foundation
Ashley Finan, Nuclear Innovation Alliance
Todd Allen, University of Wisconsin at Madison
Elina Teplinsky, Pillsbury Winthrop Shaw Pittman LLP