Testimony of

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Subcommittee on Energy
Committee on Science, Space and Technology
United States House of Representatives

December 3, 2015

Good morning Chairman Weber, Ranking Member Grayson, Chairman Smith, and Ranking Member Johnson and Members of the Subcommittee. I would like to thank Chairman Weber, Ranking Member Johnson, and Chairman Smith for introducing H.R. 4084, the Nuclear Energy Innovation Capabilities Act. This bill comes at a very important time in the history of nuclear power and clean energy.

And a hello to my fellow hearing participants, Mr. Kotek and Dr. Klein.

Rothrock Background

I have been a venture capitalist since 1988 starting out at Venrock (the Rockefeller family's venture capital vehicle), and an engineer before that including 5 years as a professional nuclear engineer having trained at Texas A&M and MIT. While at Venrock, I personally sponsored and backed 53 companies. Seven of my companies successfully complete initial public offerings or IPOs. Another three dozen had successful outcomes. Rising to managing partner at Venrock in 2000, I successfully raised three separate venture funds and participated in the investment of Venrock into some 300 deals by my other partners. My track record resulted in my being listed two times on the Forbes Midas list and ultimately being elected by my peers to be Chairman of the National Venture Capital Association in 2012-13. Unique to my nuclear background, one deal I lead at Venrock was the investment in Tri Alpha Energy, a nuclear fusion company, in 2005 and on whose board I remain to this day. I retired from Venrock in 2013 to pursue other interests

including the one I am discussing today. In full disclosure, subsequent to my retirement I personally invested in TransAtomic Power and whose board I chair. I represent myself today in this hearing.

At the height of the energy investment boom in venture capital, I was asked to testify to the Blue Ribbon Commission on America's Nuclear Future from the perspective of a venture capitalist and address the question -- could venture capital play a role in America's nuclear renaissance as it was then called. My training and experience as a nuclear engineer plus the professional expertise of knowing how to build a company from scratch, raise capital for it, and take it to market made me uniquely qualified for this task. In preparation for that testimony I reached out across the nuclear and venture industries including many of my nuclear peers. I interviewed much of the leadership in the nuclear industry, public and private, and many energy oriented venture capitalists. And of course, a wide swath of potential investors in nuclear not just venture capitalists. Regrettably, my conclusion was not encouraging and I reported it as such to the Commission. This experience, however, started me thinking about what needed to change and so I began a new journey to change the outcome I had presented to the BRC.

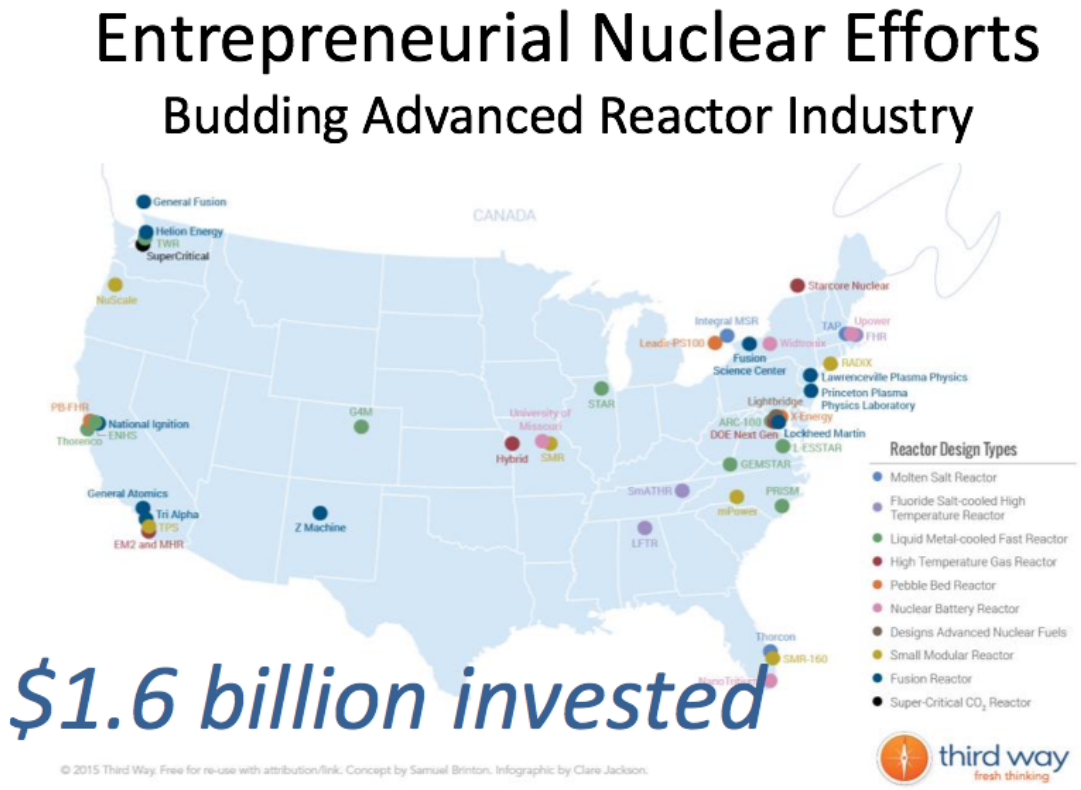
A personal result of the BRC work was that I built an incredible network of nuclear interested entrepreneurs, investors and other folks. I became a co-executive producer of Robert Stone's documentary *Pandora's Promise*. This film was a narrative addressing the large issues of nuclear energy through the eyes of five world-class environmentalists who had done the work through their personal investigations that caused each of them to flip to nuclear advocacy from their previous anti-nuclear positions. At the end of this movie's world-wide run seen by 2 million people, I assembled about 30 people involved in the film at my home in March of 2013 to address the question, "Now what?" From there a smaller team of us began this journey. To my surprise, it would take me to the DOE, the White House, the NRC, many selected senators and congressman, and now in front of you, the House Subcommittee on Energy.

My team came to several broad conclusions. Today, as requested, I will address one of those conclusions, specifically our work and recommendations as they pertain to H.R. 4084, and in particular the access and use of national

laboratory capabilities for the private sector, the nuclear innovation private sector.

Why Nuclear Power Now?

Bill H.R. 4084 would be irrelevant today if it were not for the fact that we found over 40 nuclear energy startups in North America. These companies are backed by at least $1.6 billion private capital dollars. ThirdWay based here in Washington documented more completely this finding and published it as shown in the figure below.



The needs among these start up companies are very similar. All will need patient investors with deep pockets, modern computational capability, nuclear qualified laboratory space to prove their designs, and ultimately approval by the Nuclear Regulatory Commission to take their designs to market. This finding of 40+ startups was very exciting, and was a surprise to virtually everyone in the field, including those in the government.

From my interviews I learned that the main motivation of these entrepreneurs was the need for better nuclear power to address the demand for clean energy electricity generation in the face of climate change. All of these entrepreneurs understand the need for their products to be affordable, safer, more proliferation resistant and reliable. They will not compromise on any of these requirements.

These entrepreneurs know that the current fleet of light water reactors is coming to the end of its life. They know the current designs remain expensive and require a sophisticated economy and work force to deploy. Therefore, they all concluded that there is a need for new nuclear reactor designs that can compete with the low price of natural gas, that would have better safety margins, that can potentially consume existing spent fuel waste, and that can provide richer protections against proliferation and be easily deployed around the world. They know this is a global opportunity, not just one for the United States, but that the United States is uniquely qualified to lead the world. They know that the United States was once the leader in nuclear power but is now at risk of losing that leadership.

With the exception of current small modular reactor (SMR) designs, most of these new entrepreneurial designs are not traditional light water designs, and have come to be known as "advanced nuclear energy technologies." Many of the design criteria for the SMR today was part of the reactor that I operated, Yankee Atomic (now decommissioned), in the late 1970s. Similarly, some of these new non-light water designs being developed today are old ideas dusted off from the 1950s and 1960 (some even built and tested at the Idaho Testing Station back in the day), but are greatly improved upon with state-of-the-art capabilities that we have subsequently developed over several decades.

There are countless national interviews, YouTube videos, TED Talks, and the like by these entrepreneurs talking about their ideas, and their desire to do this in the United States. I encourage you to review them. It's an impressive and patriotic lot.

Venture Success: Many Shots On Goal

The best solutions come to market when there are many groups working on similar problems. As a venture capitalist I have witnessed time and time again the results of having many startups in one particular sector attack a particular problem. We call it, "many shots on goal." There is also the element of speed. Each of these little companies works fast to out compete each other. Ultimately, the market decides the winner or winners. But ultimately the result is everyone wins – customers, companies, inventors, investors, and the public – because the problem is solved.

Many shots on goal requires many ideas, many innovations and entrepreneurs but also many sources of capital. It would appear from the evidence we found of the 40+ start up companies in advanced nuclear energy that this condition is met. But more is required.

Market Signals Required

The investors in these start ups hope to some day make a return on their investment. They know that these investments may take a long time to mature. All of us investors know this going in. These early investments are very risky and we could lose our money. But, to start a project, every investor wants to see a path to success, even if it is long. However, in the United States the pathway for advanced nuclear is uniquely difficult, perhaps even blocked at certain points.

The earliest investors and entrepreneurs believe that a path will emerge. That said, they know that if a path does not emerge, or at least a signal that a path is being created, they will need to go elsewhere, as in overseas, to finish their designs and bring product to market. This is not a very optimistic outlook, but it is an alternative.

A goal for this Committee, the Nuclear Regulatory Commission, the White House, the Department of Energy, the national laboratories, and the entire nuclear establishment in the United States should be to establish a credible **signal** for a way forward for the advanced nuclear entrepreneurs and investors willing to take the risk. The signal must be loud and clear. The ultimate path must be believable and doable in a reasonable time frame. If not, then the investors will go away and the entrepreneurs will seek other

jurisdictions in which to operate resulting in the United States losing this new found market of advanced nuclear innovation.

First Signal: Entrepreneurial Partnership with the Government

For good and obvious reasons, nuclear development by its very nature and by law requires a partnership with the Government. Today a partnership with the US Government is not clear, not easy, and often simply not possible. Every entrepreneur knows that ultimately for a new reactor concept to be accepted for commercial deployment, it will need to be built at some scale, its economics demonstrated, its design tested and safety measured, and finally approved by the Nuclear Regulatory Commission. This cannot be done in a garage in Silicon Valley, or even a private well funded laboratory in New Mexico. It requires working in facilities that are nuclear qualified with some government oversight -- a national laboratory. But the labs offer so much more than simply a safe and controlled place to do the work. The concepts introduced in H.R. Bill 4084 of a Nuclear Innovation Facility in the United States is a great idea, well timed, and desperately needed. Our national labs owned by the Department of Energy are the finest in the world. I'm personally told by their leaders that they are hungry to assist.

The bill's concept is very complementary to the conclusions of my nuclear innovation work. The signal sent by the passage of this bill would be hugely positive for all concerned. I cannot speak for the labs, but I can speak for the entrepreneurs and investors. Having reasonably priced access to nuclear capable facilities, appropriate materials, computational capability, and skilled professionals who can assist with their inventions and innovations would be a great result for this nascent industry. For sure it would quicken the time to market of new designs, increase the fidelity of the result, and if the NRC were embedded in the process, hopefully it would shorten the ultimate review of their work. Speed is a key element for success and I see this bill as increasing the speed of industry development.

I wish to note and congratulate the Department of Energy, Secretary Moniz, Acting Assistant Secretary, Office of Nuclear Energy Kotek, INL Director Dr. Mark Peters and the many other DOE personnel who crafted the GAIN (Gateway for Accelerated Innovation in Nuclear) program that was announced at the White House Summit on Nuclear Energy a few weeks ago. It is compelling, attractive to the private sector and appears to be a great first step. Like all the thousands of business plans I have reviewed over my career with

ambitious goals, it's now all in the execution, the commitment to overcome hurdles, and the willingness to solve problems.

I know this can work because there is at least one other example of a successful private-public partnership in the United States of a similar nature. This is the Mojave Air and Space Port in Mojave, California. When I visited this facility in 2013, which is a retired Marine Corps Auxiliary Station, it housed 27 separate aerospace companies and suppliers, domestic and foreign, with approximately $3 billion of backing from various sources including the private sector. These companies share people, know-how, equipment, and learnings. This ability to share and move fast makes for comradery and team work. Sharing capital equipment and know-how is a huge stated benefit of the base. The most notable residents are Scale Composites and Virgin Galactic operations where both SpaceShip 1 and 2 have been developed and flown. This is a facility operated under the auspices of the FAA but by a qualified private corporation. This may be a good model from which to start a nuclear innovation center.

Second Signal: Operating Concepts of a Nuclear Innovation Facility

I've surveyed many advanced nuclear companies to compile the following list of operating concepts for an innovation facility. The DOE should conduct a broader more complete survey as discussed in the Bill to determine more precisely the needs of the advanced reactor entrepreneurs. But here is my expert entrepreneurial-investor position.

1. A program like this should have a single point of contact for advanced nuclear startups to simplify and speed the process.
2. Private companies should be required to submit a complete work plan to be reviewed by the local facility for fit, performance, and capability. Laboratory professionals may participate in the work plan for completeness and credibility. The final review process should be simple, clear, and independent of the interested parties within the lab, hence an independent but local committee and lab executive approval required. Thirty-day review max. Time is the enemy of a startup.
3. The private company needs to demonstrate financial wherewithal to complete the project. Production of financial statements or other means of proof is required.

4. The budget should be largely known before the work starts. The private company should pay for all variable direct costs of materials, labor, compute, and consumables. This should not be a source of profit for the lab. The lab is already paid for, the labor secure, and the investment by the taxpayers complete.
5. To encourage application and partnership, some form of grant may be considered. After talking to several lab directors, I've learned that there is a complicated accounting and excessive overhead charges that exists at the labs. The current methods with their very high costs would discourage applications from startups with modest budgets. Something new is required. In the event the accounting can't be changed, then perhaps Congress/DOE can create an "innovation program" that fills in the accounting gap. This is not a cash item. For example, the private company spends $1 dollar; the lab credits the startup with $2 or some such leverage to satisfy lab accounting overhead rules. A detail – yes. But a very important detail because startups can only pay market rates and labs as I understand it, are well above market rates, and are already paid for.
6. Laboratory skilled personnel should be embedded in the project for maximum leverage of knowhow, safety, resource access and benefit to both the lab and the private company. They cannot, however, impede the speed of progress such as with divided duties or different masters – they will "work" for the innovation company.
7. Intellectual property developed by the private company while in the lab facility belongs to the private company. Should any lab personnel participate in the direct invention, then appropriate accommodation of that intellectual property ownership be applied.
8. The liability for incidents, like all things in this field, should be understood and crystal clear to all parties. The concept of a bond as collateral is not common in startup companies.
9. Safety procedures, training, health physics safety and training, should be available and required for all private employees who use these facilities. Oversight for this function belongs with the lab.
10. Information sharing and consultation with appropriate NRC personnel should be encouraged if not required. This learning and knowledge sharing should be applied and hopefully speed along any ultimate license review. Sharing will increase speed of learning.

11. One question that pops up and one that I have pressed both at the DOE and with legal experts is: can an advanced reactor company build a prototype at a DOE facility without the NRC approval? Legally this was asked and answered years ago. But today there is considerable confusion and opinions vary within nuclear establishment on this matter. I would ask that some clarification be provided as this would be an important part of the path to commercialization for any new reactor design. And if that question remains unclear, it's a question that I would encourage Congress to resolve to allow companies to prove their concepts at a DOE laboratory.

Third Signal: Nuclear Regulatory Process

I feel compelled to report to you my findings on this most important matter of nuclear regulation though it was not specifically asked of me. It is as important as anything else I have found.

The NRC is the world's finest regulatory body for nuclear power. It has done its job exceedingly well. The evidence is prima facie given the incredible safety track record of the commercial nuclear power industry. However, the NRC's capability to entertain and evaluate new nuclear technologies has been severely limited or diminished. This is simply an artifact of history, not a commission of error. As it stands, the current processes will not work for the advanced nuclear industry. If you ask, you will hear from the NRC that it can indeed accommodate the advanced nuclear designs. My experience is just the opposite. Let me explain.

I first discovered this fact when conducting due diligence on a potential NuScale investment by Venrock in 2008. Despite the technical merit, the team merit, and the even the capital requirement for NuScale, the NRC was the blocking factor in our view. The notion of spending upwards of $500 million for a licensing review with an all or nothing decision, and few intervening evaluation progress points over an unspecified period of time was unacceptable. We at Venrock have built over 100 drug companies and managed our way through a long FDA review period, so we had experience in long investing, risky technology with uncertain technical outcomes. It was the unpredictability and lack of intermediate risk mitigation steps that was unacceptable. Sadly, what we concluded at Venrock happened. I learned that

NuScale is now 15 years in the process, over $1 billion spent, and its SMR design is not yet approved nor expected before 2017. And the NuScale SMR is a light water design.

With the Clean Air Task Force as the lead, my team and I have initiated conversations with the NRC regarding new paths through the regulatory process that are technology neutral by design. There are many successful and start up acceptable processes that work well in other equally difficult technologies with enormous public benefit such as drug development with the FDA review, or airframes and the FAA.

Every advanced nuclear startup knows they have this regulatory hurdle if their designs are to get to market. As it stands, it is a **stop signal** to investors.

While I'm critical of the NRC as a startup company investor, I applaud the NRC as the gold standard for nuclear power regulation. This gold standard comes from many things and decades of results. Regrettably this gold standard applies to only light water reactors as best I can tell. That said, the NRC has a huge opportunity to lead the world in advanced reactor regulation. Any benefits to the current licensing and review systems, of course, would be a benefit to all applicants including current light water designs, SMRs, and advanced nuclear designs.

Conclusions and Summary

A summary of my testimony and the key observations from the stand point of an advanced nuclear innovation company and its investors follows.

1. There is a vibrant but nascent advanced nuclear innovation ecosystem in the United States – over forty companies backed by at least $1.6 billion in private capital.
2. "Many shots on goal" and time to market are essential elements in a successful innovation ecosystem – the Silicon Valley has proven that. The advanced nuclear reactor startup ecosystem is no different. A national lab is the perfect place for an advanced reactor innovation ecosystem to be established. The United States DOE Labs are the finest

in the world and an incredible resource already in place and ready to assist.

3. To succeed in nuclear in the United States, US Government oversight is required by law. The advanced nuclear startups cannot act alone. There are certain government roadblocks and speed bumps in the road to their success. Therefore, these new companies need a good partner in the US Government/Department of Energy/NRC to complete their work and have a chance for commercial success.
4. The Nuclear Regulatory framework currently in use in the United States is not suitable in structure, ability, or capability to address the needs of an advanced nuclear design. This may need to be addressed through Congressional action.
5. The United States has led the world in nuclear energy since the discovery of fission. The new generation of scientists and engineers understand the need for advanced nuclear power to address the challenges of their time – affordable, reliable, clean electric power for the world. This advantage of the United States is ours to lose.

I support bill H.R. 4084. I hope this and others that may follow can once again put the United States in a position of world nuclear power leadership especially in light of the demands to reduce the carbon footprint of the electric generation sector.

Thank you Chairman Weber for this opportunity to address the Subcommittee on Energy. I remain at your service in these or any effort to achieve the goal of advanced affordable, reliable, safer, clean nuclear energy.

RAY A. ROTHROCK

RedSeal Chairman and CEO
Venrock Partner Emeritus
National Venture Capital Assn. former Chairman

RedSeal CEO Ray Rothrock is a long-time thought leader in cyber security and a successful investor in the sector. He joined RedSeal as CEO in February 2014. Focusing early on Internet infrastructure and security, he has an extraordinary track record in cybersecurity investments. He often consults on trends, strategies and technologies in cybersecurity markets. Earlier this year, Ray attended the White House CyberSecurity Summit held at Stanford University.

Prior to RedSeal Ray was a managing general partner at Venrock retiring in 2013 after 25 years. At Venrock, he invested in 53 companies including more than a dozen in cybersecurity, including Check Point Software, Vontu, PGP, P-Cube, Imperva, Cloudflare, CTERA, and Shape Security in addition to leading the energy investment program and the Internet investment program in the firm. He remains on the board of Check Point Software (NASDAQ: CHKP) and several other Venrock investments. Ray was the 2012-13 chairman of the National Venture Capital Association.

Ray's successful investments include seven IPOs -- Spyglass, DoubleClick, Digex, USInternetworking, FogDog Sports, Check Point Software and Imperva -- and many successful M&A events, including Pedestal, Haystack Labs, P-Cube, Whole Security, Vontu, PGP and Qpass. As a result of his excellent track record Ray has been listed twice on the Forbes Midas lists.

He continues to invest on his own account and support a number of startup companies through board service. Namely he serves on the boards of Team 8, Roku, Colabo, Transatomic Power, Tri Alpha Energy, GenBand and Premier Coiled Tubing and an advisor to many entrepreneurs.

An engineer at heart, Ray has a keen insight into products, markets and how people are impacted by technology. He began his career as a nuclear engineer with Yankee Atomic Electric, and Exxon Minerals' nuclear operations. Before joining Venrock, he participated in three Silicon Valley venture capital-backed companies – two that failed and the very successful Sun Microsystems. These experiences introduced him to venture capital and the

thrills and risk involved in startup enterprises. When he joined Venrock, he launched the firm's Internet and energy practices.

SERVICE ACTIVITIES

Ray is presently a member of the board of the MIT Corporation where he also sits on the Music and Theatre Arts, Linguistics and Philosophy, and Chemical Engineer Visiting Committees at MIT. Ray served as the 2012-2013 Chairman of the National Venture Capital Association a position elected by his industry peers. In 2010 he was requested and testified to the President's Blue Ribbon Commission on America's Nuclear Future. He also has served on the Board of Trustees of the Texas A&M Foundation (2003-2010) where he chaired the Investment Committee (2007-2010), was an Executive in Residence at the Harvard Business School (2011-2013) and an Executive in Residence at Middlebury College (2011-2012) and served a decade on the Visiting Committee of the MIT Nuclear Science and Engineering Department ending in 2011. He is on the board of and is a past chair of Woodside Priory School in Portola Valley, California. While chair of Priory, he chaired a $25 million capital campaign. He also is a trustee of TheatreWorks Silicon Valley, a regional theatrical company in Palo Alto, California. He served on the Tau Beta Pi Vision Development Board. Ray serves as a member of the Portola Valley Emergency Preparedness Committee and has served numerous times as chairman of those activities. Ray targets his philanthropic interests primarily at climate change, education and the performing arts.

ADVOCACY

In 2012, along with others he co-produced the documentary Pandora's Promise, directed by Robert Stone. Seen by over 2 million people, this movie about nuclear energy and the energy demands of the human race lead to the creation of Nuclear Reimagined, an advanced nuclear energy advocacy organization. Ray leads this group and has been invited to testify and present to Congress and the Department of Energy, and was selected to participate in a private White House convening entitled, Nuclear Energy Technology Innovation: The Road Ahead. He attended the White House Summit on Nuclear Energy. He is also a founding member and board member of the Nuclear Innovation Alliance.

AWARDS

In 2012 he received the Distinguished Alumnus Award from the Nuclear Engineering and Science department of MIT. In 2013 he received the Distinguished Engineer Award and in 2012 the Distinguished Service Award in Liberal Arts, both from Texas A&M University. In 2015 he received the Distinguished Alumnus Award from Tau Beta Pi, the national engineering honor society.

Ray holds a Professional Engineering License, Texas. He is an Eagle Scout from Fort Worth, TX. He and his son have a rock and roll cover band, "Up and to the Right" regularly performing in the Silicon Valley. Follow him on Twitter. @rayrothrock

EDUCATION

1977 Texas A&M University, B.S. Nuclear Engineering, Summa Cum Laude
1978 M.I.T., S.M., Nuclear Engineering
1988 Harvard Business School, MBA with Distinction

PROFESSIONAL

1978 Yankee Atomic Electric Company, Westborough, MA
1980 Exxon Minerals, Houston, TX
1981 Sagus Engineering, Campbell, CA
1982 Impell Corporation, San Francisco, CA
1984 Sun Microsystems, Mountain View, CA
1988 Venrock Associates, New York City, NY and Palo Alto, CA
2013 Private Venture Capitalist, Portola Valley, CA
2014 RedSeal, Chairman and CEO, Sunnyvale, CA