H.R. 4084, NUCLEAR ENERGY INNOVATION CAPABILITIES ACT

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

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December 3, 2015

H.R. 4084, NUCLEAR ENERGY INNOVATION CAPABILITIES ACT

THURSDAY, DECEMBER 3, 2015

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:07 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Randy Weber [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
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EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

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COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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Subcommittee on Energy

H.R. 4084, the Nuclear Energy Innovation Capabilities Act

Thursday, December 3, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. John Kotek, Acting Assistant Secretary, Office of Nuclear Energy, U.S. Department of Energy

Dr. Dale Klein, Associate Vice Chancellor for Research, University of Texas

Mr. Ray Rothrock, Partner Emeritus, Venrock

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

HEARING CHARTER

H.R. 4084, the Nuclear Energy Innovation Capabilities Act

December 3, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The Energy Subcommittee will hold a legislative hearing on *H.R. 4084, the Nuclear Energy Innovation Capabilities Act*, on Thursday, December 3rd, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Witnesses

- **Mr. John Kotek**, Acting Assistant Secretary, Office of Nuclear Energy, U.S. Department of Energy
- **Dr. Dale Klein**, Associate Vice Chancellor for Research, University of Texas
- **Mr. Ray Rothrock**, Partner Emeritus, Venrock

Background

On November 19, 2015, Energy Subcommittee Chairman Randy Weber (R-TX), Ranking Member Eddie Bernice Johnson (D-TX), and Chairman Lamar Smith (R-TX), along with 18 cosponsors, introduced H.R. 4084, the Nuclear Energy Innovation Capabilities Act.[1]

The Department of Energy's (DOE's) national laboratory complex originated from the Manhattan Project and since then has provided the facilities and expertise necessary to conduct research and development (R&D) for military and civilian applications of nuclear energy.[2] DOE carries out civilian nuclear energy R&D through the DOE labs and universities which provide research infrastructure and employ highly trained scientists to maintain the nation's critical R&D capabilities.

H.R. 4084 directs the DOE to prioritize R&D infrastructure that will enable the private sector to invest in advanced reactor technologies in the United States. This legislation also

[1] Additional list of original cosponsors for H.R. 4084, as follows: Reps. Daniel Lipinski (D-IL), Barry Loudermilk (R-GA), Ed Perlmutter (D-CO), Barbara Comstock (R-VA), Paul Tonko (D-NY), Jim Bridenstine (R-OK), Brian Babin (R-TX), Dana Rohrabacher (R-CA), Randy Hultgren (R-IL), Bruce Westerman (R-AR), David Schweikert (R-AZ), John Culberson (R-TX), Kevin Brady (R-TX), Pete Sessions (R-TX), John Carter (R-TX), Michael Conaway (R-TX), Kenny Marchant (R-TX), and Blake Farenthold (R-TX).
[2] See http://energy.gov/management/office-management/operational-management/history/manhattan-project

requires the DOE to provide a clear path forward to enable private investment for reactor prototype development at DOE labs while exploring opportunities to leverage expertise from the Nuclear Regulatory Commission (NRC). The United States' regulatory process for commercial nuclear R&D has not kept pace with technological development, in part because the NRC draws its funds from fees assessed to its licensees to review a single class of reactors.[3]

Section-by-Section Summary

- Section 1 provides a short title: "Nuclear Energy Innovation Capabilities Act."
- Section 2 provides technical definitions.
- Section 3 amends DOE's civilian nuclear energy R&D mission to ensure that the DOE enables the private sector to partner with national labs for the purpose of developing novel reactor concepts.
- Section 4 provides a sense of congress that nuclear fission and fusion represent an opportunity for high energy density, zero air-emissions technology development of national importance to scientific progress, national security, energy R&D, and space exploration.
- Section 5 provides programmatic authority for DOE to leverage its supercomputing infrastructure to accelerate nuclear energy R&D capabilities for advanced fission and fusion reactor technologies.[4]
- Section 6 provides the DOE with statutory direction for a reactor-based fast neutron source that will operate as an open-access user facility to enable academic and proprietary research in the United States.[5]
- Section 7 authorizes DOE to enable the private sector to construct and operate privately-funded reactor prototypes at DOE sites.[6]
- Section 8 requires DOE to produce a transparent, strategic, 10-year plan for prioritizing nuclear R&D programs while considering budget constraints.

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[3] *A Review of the Nuclear Regulatory Commission's Licensing Process: Hearing Before the Subcomm. on Energy of the H. Comm. on Science, Space, and Technology*, 114th Cong. (2015), available here: https://science.house.gov/legislation/hearings/subcommittee-energy-hearing-review-nuclear-regulatory-commission-s-licensing

[4] *Supercomputing and American Technology Leadership: Hearing Before the Subcomm. on Energy of the H. Comm. on Science, Space, and Technology*, 114th Cong. (2015), available here: https://science.house.gov/legislation/hearings/subcommittee-energy-supercomputing-and-american-technology-leadership. See also *Department of Energy Oversight: Energy Innovation Hubs: Hearing Before the Subcomm. on Energy of the H. Comm. on Science, Space, and Technology*, 114th Cong. (2015), available here https://science.house.gov/legislation/hearings/subcommittee-energy-hearing-department-energy-oversight-energy-innovation-hubs

[5] *Nuclear Energy Innovation and the National Labs: Hearing Before the Subcomm. on Energy of the H. Comm. on Science, Space, and Technology*, 114th Cong. (2015), available here: https://science.house.gov/legislation/hearings/subcommittee-energy-hearing-nuclear-energy-innovation-and-national-labs

[6] *The Future of Nuclear Energy: Hearing Before the Subcomm. on Energy of the H. Comm. on Science, Space, and Technology*, 113th Cong. (2014), available here: https://science.house.gov/legislation/hearings/energy-subcommittee-future-nuclear-energy

Chairman WEBER. The Subcommittee on Energy will come to order.

Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time, and we expect votes to be called just any minute.

Welcome to today's hearing entitled "H.R. 4084, the Nuclear Energy Innovation Capabilities Act."

I am going to defer my opening statement. I know the Chairman has graciously agreed to, and the Ranking Member has also, to be put in the record. So good morning. I thank you all for coming. And I would like to thank Ranking Member Johnson, who's not here, and Chairman Smith for cosponsoring this bill with me. It is an absolute honor to work with fellow Texans to establish policies that keep America globally competitive, support innovation in our economy, and actually promote national security goals. And I would also like to think other cosponsors from this Science Committee.

As the Energy Subcommittee's legislative business for 2015 draws to a close, we're going to be work with this stuff. You can read the rest of my statement in the record.

[The prepared statement of Chairman Weber follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
December 3, 2015

Media Contact: Zachary Kurz
(202) 225-6371

Statement of Energy Subcommittee Chairman Randy Weber (R-Texas)
H.R. 4084, the Nuclear Energy Innovation Capabilities Act

Chairman Weber: Good morning and welcome to today's Energy Subcommittee hearing on H.R. 4084, the Nuclear Energy Innovation Capabilities Act.

First, I would like to thank Ranking Member Johnson and Chairman Smith for cosponsoring this bill with me. It is an honor to work with fellow Texans to establish policies that keep America globally competitive, support innovation in our economy, and promote national security goals. I would also like to thank the other original cosponsors from the Science Committee.

As the Energy Subcommittee's legislative business for 2015 draws to a close, I'd like to take a few minutes to review this year's hearing record to explain how we got to where we are.

In January, the very first subcommittee hearing was titled "Super Computing and American Technology Leadership." That title pretty much sums up what we intend to accomplish with H.R. 4084. First, we provide DOE with statutory direction to leverage its supercomputing infrastructure for modeling and simulation capabilities to develop advanced fission and fusion reactors.

Second, the bill lays out a clear timeline and statutory guidance for DOE to complete a research reactor that will allow for materials and fuels R&D to take place in the United States. Currently this type of research which requires access to fast neutrons is only accessible for civilian use in Russia. In May, we heard from witnesses representing Argonne National Lab and General Atomics testifying on this type of research infrastructure that *enables* research to happen. In June, the Director of the DOE Energy Innovation Hub for modeling and simulation, known as CASL (pronounced "Castle"), explained how modeling and simulation can eliminate simplifying assumptions to accelerate R&D, but this research must be validated through a physical source, which is precisely what the versatile neutron source under Section 6 of H.R. 4084 will enable.

Third, this legislation provides DOE with statutory direction to use its authority to enable the national labs to partner with the private sector to construct and operate reactor prototypes at DOE sites while leveraging expertise from the Nuclear Regulatory Commission. On the technology side, this is a simple concept. Engineers require a certain degree of freedom to bring creative ideas from conception to prototype. Nuclear reactors, however, are expensive and highly regulated, which tends to cause problems for the folks trying to design first-of-a-kind reactors that could actually increase safety in the long run.

This legislation is of critical importance. We have to maintain our R&D capabilities to develop cutting edge nuclear technology here in America or in the not-too-distant future, we'll be importing reactors from overseas. Furthermore, we cannot afford to lose engineering and manufacturing jobs in the nuclear

sector when we have the best talent in the world right now. America's export economy is a key to our global strength and this bill will provide a long term plan to ensure that we that we do not lose our talent.

Perhaps of greater importance is the need to maintain America's capability to influence security and proliferation standards around the world as more developing nations turn to nuclear energy. As a member of the Foreign Affairs Committee, I am constantly reminded about the dangers our nation faces in this turbulent world. H.R. 4084 makes it clear that the United States will not turn a blind eye to this critical area of technology.

I thank this distinguished panel of witnesses for their attendance today and I look forward to their testimony.

###

Chairman WEBER. With that, I'm going to introduce the witnesses. Our first witness today is Mr. John Kotek, Acting Assistant Secretary for the Office of Nuclear Energy at the DOE. Mr. Kotek previously served as the Principal Deputy Assistant Secretary for the Office of Nuclear Energy. In addition, Mr. Kotek—am I pronouncing that correct—okay—received his bachelor's degree in nuclear engineering from the University of Illinois and his MBA from the University of Maryland.

I will now yield to the Chairman of the full Committee, Mr. Smith, to introduce our second witness.

Chairman SMITH. Thank you, Mr. Chairman.

Our second witness today is Dr. Dale Klein, Associate Vice Chancellor for Research for the University of Texas System. In 2006, Dr. Klein joined the Nuclear Regulatory Commission and was later appointed Chairman by President Bush, where he served until 2010. As Chairman, Dr. Klein was the Principal Executive Officer and Official Spokesman for the NRC. He was responsible for the administrative, organizational and long-range planning, budgetary, and personnel functions of the agency. Prior to joining the NRC, Dr. Klein was the Assistant to the Secretary of Defense for Nuclear, Chemical, and Biological Defense programs. He also served as the Vice Chancellor for Special Engineering Programs at the University of Texas and as a Professor in the Department of Mechanical Engineering at the University of Texas. Dr. Klein holds a Ph.D. in nuclear engineering from the University of Missouri.

Dr. Klein, thank you for making the trip from Austin today. We look forward to your testimony.

[The prepared statement of Chairman Smith follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
December 3, 2015

Media Contact: Zachary Kurz
(202) 225-6371

Statement of Chairman Lamar Smith (R-Texas)
H.R. 4084, the Nuclear Energy Innovation Capabilities Act

Chairman Smith: I thank my fellow Texans on the Committee, Randy Weber, Chairman of the Energy Subcommittee, and Eddie Bernice Johnson, Ranking Member of the Science Committee, for introducing this legislation.

I am glad to be a cosponsor of this bipartisan legislation along with many other members of the Science Committee, which include Representatives Lipinski, Loudermilk, Perlmutter, Comstock, Tonko, Bridenstine, Babin, Rohrabacher, Hultgren, and Westerman.

Today's hearing will examine H.R. 4084, the "Nuclear Energy Innovation Capabilities Act."

H.R. 4084 provides the Department of Energy (DOE) with the resources it needs to develop long term research and development (R&D) planning and infrastructure within its Office of Nuclear Energy.

These are the types of R&D investments that do not yield major rewards or profits in the short term, but provide the necessary capabilities for technology development that only the federal government has the ability to support.

This legislation authorizes DOE to take advantage of America's supercomputers in order to accelerate R&D for advanced fission and fusion reactor concepts with the help and expertise of the private sector, universities, and national labs.

The bill also puts forth a hard timeline for DOE to complete a research reactor within 10 years that will enable proprietary and academic research to validate supercomputing models.

Finally, H.R. 4084 creates a reliable mechanism for the private sector to partner with DOE labs and develop advanced fission and fusion prototype reactors at DOE sites.

Nuclear power has been a proven source of safe and emission-free electricity for over half a century since it was first developed in the United States.

However, our ability to move from R&D to market deployment has been hampered by government red tape. The U.S. has not lived up to its potential when it comes to nuclear energy.

The regulatory process is cumbersome and lacks the certainty needed for sustained investment in new nuclear energy technology.

This legislation enables our talented engineers in the private sector, academia, and at the national labs to develop the next generation of nuclear technology here in the United States.

It produces bipartisan long term R&D investments that will help spur American competitiveness and keep us on the forefront of nuclear energy technology.

###

Chairman WEBER. Thank you, Chairman Smith.

Our final witness today is Mr. Ray Rothrock, Partner Emeritus of Venrock. Mr. Rothrock has had a career in venture capital spanning over 25 years, successfully investing in over 50 startup companies. Mr. Rothrock received his bachelor's degree in nuclear engineering from Texas A&M, his master's degree in nuclear engineering from MIT, and his MBA from Harvard.

I now recognize Mr. Kotek for five minutes to present his testimony.

TESTIMONY OF MR. JOHN KOTEK,
ACTING ASSISTANT SECRETARY,
OFFICE OF NUCLEAR ENERGY,
U.S. DEPARTMENT OF ENERGY

Mr. KOTEK. Thank you, Chairman Weber, Ranking Member Grayson, and Members of the Committee. Thank you for the invitation to testify at today's hearing.

I appreciate the Committee's interest in research and development of advanced nuclear energy technologies.

The Department of Energy does not have a position on the legislation but it is consistent with much of the work currently being done by DOE.

As has been noted before this Committee in the past, nuclear energy continues to play a vital role in the President's energy strategy for a sustainable, clean energy future. Nuclear energy has provided nearly 20 percent of electrical generation in the United States over the past two decades and currently produces more than 60 percent of America's carbon-free electricity.

As the United States leads the global transition to a low-carbon economy, the continued development of new and advanced nuclear energy technologies along with support for currently operating nuclear power plants is an important component of our clean energy strategy.

Because nuclear energy innovation is at the heart of today's hearing, let me focus my oral remarks on DOE's research and development programs for advanced reactor technologies.

Future-generation reactor systems may employ advanced technologies and designs to improve performance beyond what is currently available. More advanced reactor designs with coolants other than light water, often referred to as generation IV designs, may enable reactors to operate at higher temperatures and with increased efficiencies. Continued R&D in this area is essential for the long-term prospects of nuclear energy.

Advanced reactor technologies considered in DOE's R&D program reside at different technology maturity levels with R&D efforts mainly focused on three advanced concepts: liquid metal-cooled fast reactors, fluoride salt-cooled high-temperature reactors, and high-temperature gas-cooled reactors.

DOE has also initiated studies on how to optimize the integration of nuclear energy and variable renewable energy sources through collaboration between my office and the Office of Energy Efficiency and Renewable Energy. These studies will not only examine integration of current light water reactor technology, but

also advanced reactor technologies that have the potential to provide high-temperature process heat in addition to electricity.

As noted in the proposed legislation, investments in the infrastructure to support advancement of nuclear technology are also critical. Research, development, and demonstration programs are dependent on an infrastructure of experimental and computational facilities, access to critical materials and data, and highly trained scientists and engineers dedicated to meeting the needs of the nation.

The proposed legislation identifies three specific requirements for DOE to address in the areas of high-performance computing and supportive research, a versatile neutron source, and enabling nuclear energy innovation. NE programs are currently working across these three critical areas.

The Consortium for Advanced Simulation of Light Water Reactors or CASL, a DOE Energy Innovation Hub centered at Oak Ridge National Lab, was established to provide leading-edge modeling and simulation capability to improve the performance of currently operating reactors. This successful program has now expanded beyond operating reactors to support modeling and simulation for small modular reactors. Additionally, our Nuclear Energy Advanced Modeling and Simulation program is addressing modeling and simulation needs for nuclear fuels and for advanced nuclear reactors. As these tools are developed and integrated, NEAMS will be able to provide nuclear technology designers with a truly predictive capability that spans from the fuel pellets to the entire plant to better predict the performance, reliability and economics of advanced nuclear power plants.

With respect to a new versatile neutron source, DOE is evaluating the potential need for a new research reactor capability. To support the development of advanced reactor technology options, the Department has undertaken a study to determine the needs of the advanced nuclear reactor community and to develop options, including the key features and timing for a possible advanced test or demonstration reactor to support research, development and demonstration, and eventual commercialization of advanced reactor systems.

And finally, with respect to enabling nuclear energy innovation, NE identified that improvements can be made to accelerate the innovation of nuclear technologies. To further enable this goal, NE launched the Gateway for Accelerated Innovation in Nuclear, or GAIN, during last month's White House Summit on Nuclear Energy. GAIN will provide the nuclear energy community with a single point of access to the broad range of resources, people, facilities, materials and data at our Idaho National Lab and across the DOE complex. Focused research opportunities and dedicated industry engagement will also be an important component of GAIN, ensuring that DOE-sponsored activities are impactful to companies working to realize the full potential of nuclear energy.

Chairman Weber, Ranking Member Grayson and members of the Committee, thank you again for inviting me to discuss this legislation and the work that the Department and the Office of Nuclear Energy are currently doing, and I'd be happy to answer any questions.

[The prepared statement of Mr. Kotek follows:]

Statement of John F. Kotek
Acting Assistant Secretary for Nuclear Energy
U.S. Department of Energy
Before the
Subcommittee on Energy
Committee on Science, Space and Technology
U.S. House of Representatives

December 3, 2015

Chairman Weber, Ranking Member Grayson, and members of the Committee, thank you for your invitation to testify at today's hearing on the newly introduced *Nuclear Energy Innovation Capabilities Act* (H.R. 4084). I appreciate the Committee's interest in research and development (R&D) of advanced nuclear energy technologies. The Department of Energy (DOE) does not have a position on the legislation, but it is consistent with much of the work currently being done by DOE.

As has been noted before this committee in the past, nuclear energy continues to play a vital role in the President's energy strategy for a sustainable, clean energy future. Nuclear energy has provided nearly 20 percent of electrical generation in the United States over the past two decades and currently produces nearly 60 percent of America's carbon-free electricity. As a deployable power source with a high capacity factor, nuclear power is a promising option for low-carbon baseload power. As the United States leads the global transition to a low-carbon economy, the continued development of new and advanced nuclear technologies, along with support for currently operating nuclear power plants, is an important component of our clean energy strategy. Investing in the safe and secure development of nuclear power also helps advance other vital policy objectives in the national interest, such as maintaining economic competitiveness and job creation, as well as enhancing nuclear nonproliferation efforts, nuclear safety and security, and energy security.

To ensure that nuclear energy continues to provide affordable, carbon-free power, DOE's Office of Nuclear Energy (NE) focuses its programs to: improve the reliability and performance, sustain the safety and security, and extend the life of current reactors by developing advanced technological solutions; meet the Nation's energy security and climate change goals by developing technologies to support the deployment of economically competitive advanced reactors; improve energy generation, waste management, safety, and nonproliferation attributes by developing innovative nuclear fuel cycles; maintain key infrastructure to support cutting edge research on nuclear technologies; and advance U.S. civil nuclear energy priorities and objectives through international collaboration.

In the mission section of the proposed *Nuclear Energy Innovation Capabilities Act,* the Secretary of Energy is directed to "conduct programs of civilian nuclear research, development, demonstration, and commercial application," and six specific objectives are identified: (1) Providing research infrastructure to promote scientific progress and enable users from academia, the National Laboratories, and the private sector to make scientific discoveries relevant for nuclear, chemical, and materials science engineering; (2) Maintaining National Laboratory and university nuclear energy research and

development programs, including their infrastructure; (3) Providing the technical means to reduce the likelihood of nuclear weapons proliferation and increasing confidence margins for public safety of nuclear energy systems; (4) Reducing the environmental impact of nuclear energy related activities; (5) Supporting technology transfer from the National Laboratories to the private sector, and (6) Enabling the private sector to partner with the National Laboratories to demonstrate novel reactor concepts for the purpose of resolving technical uncertainty associated with the aforementioned objectives. This mission and these objectives are all consistent with the focus of NE's programs.

OFFICE OF NUCLEAR ENERGY PROGRAMS

NE's current research programs focus on four general areas: maintaining the current fleet, performing R&D for advanced reactor technologies, developing sustainable fuel cycles, and investing in infrastructure. The work performed in these areas move forward the objectives in the proposed Act.

The Current Fleet

One of NE's key programs, Light Water Reactor Sustainability (LWRS), addresses challenges facing the continued safe and economic operation of the current fleet. NE works in conjunction with industry and, where appropriate, with the Nuclear Regulatory Commission (NRC) to support and conduct the long-term research needed to inform major component refurbishment and replacement strategies for the current fleet. These areas include performance, cyber security, and safety; as well as, long-term operations through plant license extensions.

Research performed under LWRS supports utilities seeking to operate nuclear power plants beyond 60 years. A marker of the success for this program was demonstrated last month when the first U.S. utility notified the NRC of its intent to file a second license renewal to extend operation to 80 years.

Licensing and Construction of Nuclear Reactors in the United States

Licensing and construction of new nuclear reactors are critical to meeting our clean energy future. In October, the NRC issued the operating license for Tennessee Valley Authority's Watts Bar Unit 2. This will be the first U.S. reactor to be completed this century. Additionally, construction of the first new nuclear plants in this country in more than 30 years continues for four new units, two at Plant Vogtle in Georgia and the other two at VC Summer in South Carolina. Both projects are deploying the NRC-certified, Generation III+ Westinghouse AP1000 – a new generation of passively safe reactors. Together, these newly constructed units will provide enough reliable, zero-emission, baseload electricity to power three million homes in the Southeastern United States.

Further headway has also been made with GE-Hitachi Nuclear Energy's Economic Simplified Boiling Water Reactor (ESBWR). ESBWR is a 1,600-megawatt reactor, which includes passive safety features that would cool the reactor after an accident. Earlier this year, the NRC issued the first combined license for an ESBWR for potential deployment in Michigan.

If the Nation's climate goals are to be realized, nuclear energy has to continue to be a component of the Nation's energy portfolio and barriers to the further deployment of new nuclear plants must be

overcome. Impediments to further plant deployments, even for designs based on familiar Light Water Reactor (LWR) technology, include the substantial capital cost of new plants and the uncertainties in the time required to construct those plants.

A high priority of the Department is to accelerate the timeline for commercialization and deployment of small modular reactor (SMR) technologies through the SMR Licensing Technical Support (LTS) program. The SMR LTS program is a six-year, $452 million initiative focused on first-of-a-kind engineering support for design certification and licensing activities for SMR designs through cost-shared arrangements with industry partners to promote accelerated commercialization of the nascent technology. SMRs have the potential to achieve lower upfront capital cost, modular power additions, and simpler, predictable and faster construction than other designs. The Department believes strongly that SMRs can promote American competitiveness, create manufacturing jobs here at home, and reduce CO_2 emissions through clean, safe, and reliable nuclear power. These new SMRs, as well as the AP1000 and ESBWR reactors, are designed with passive safety features to minimize any requirement for prompt operator action and to prevent auxiliary system failures.

The Department has entered into cost-shared agreements with industry. Most recently, DOE signed a cooperative agreement with NuScale Power in May 2014, providing funds to support design development and NRC design certification with deployment scheduled for the 2025 timeframe.

Research and Development for Advanced Reactor Technologies

Future-generation reactor systems may employ advanced technologies and designs to improve performance beyond what is currently attainable. More advanced reactor designs with coolants other than light water, often referred to as Generation IV designs, may enable reactors to operate at higher temperatures and with increased efficiencies – resulting in improved economics. These designs may also provide expanded fuel cycle options that can inform future policy decisions. Continued R&D in this area is essential for the long-term prospects of nuclear energy.

The Department's advanced reactor program performs research to develop technologies and subsystems that are critical for advanced concepts that could dramatically improve nuclear power performance through the achievement of goals related to sustainability, economics, safety, and proliferation resistance. Advanced reactor technologies considered in this program reside at different technology maturity levels with R&D efforts mainly focused on three advanced concepts: liquid metal-cooled fast reactors, including sodium-cooled fast reactors (SFRs); fluoride salt-cooled high-temperature reactors (FHRs); and high-temperature gas-cooled reactors (HTGR).

The Department of Energy has issued several awards over the past few years to support cost-shared R&D activities with industry totaling $16.5 million in federal funding. These projects are addressing significant technical challenges to further the design, construction, and operation of next generation nuclear reactors, based upon the R&D needs identified by industry designers and technical experts. In many cases, new technologies are being developed to enable these advanced reactor designs.

The Department has also initiated studies on how to optimize the integration of nuclear energy and variable renewable energy sources through collaboration between the Offices of Nuclear Energy and Energy Efficiency and Renewable Energy. These studies will not only examine integration of current light water reactor technology, but also advanced reactor technologies that have the potential to provide high temperature process heat in addition to higher efficiency electricity.

For the past ten years, NE has conducted research on supercritical carbon dioxide (sCO_2) Brayton cycles for use with advanced reactor concepts. Recent efforts to demonstrate this transformational energy conversion technology have been proposed in the Supercritical Transformational Electric Power (STEP) Generation Initiative which is being funded predominantly by the Office of Fossil Energy. Fossil Energy is intent on developing a directly fired supercritical CO2 system which can significantly reduce the costs of carbon capture and storage (CCS). STEP will advance this technology by developing a 10-megawatt demonstration facility under a cost-share with industry.

Investing in Research and Development Infrastructure

As noted in the proposed legislation, investments in the infrastructure to support advancement of nuclear technology are critical. Research, development, and demonstration programs are dependent on an infrastructure of experimental and computational facilities, access to critical materials and data, and highly trained scientists and engineers dedicated to meeting the needs of the Nation. The Nation's nuclear research, development, and demonstration infrastructure needs to incorporate a broad range of facilities, from small-scale laboratories to hot cells and test reactors. Computing facilities ranging from desktop workstations to parallel processors and supercomputers are routinely employed to gain new insights and guide experiment design. The high cost of creating and maintaining physical infrastructure for nuclear energy-related activities, including the necessary safety and security infrastructure, requires close alignment of infrastructure planning with programmatic needs to ensure capabilities are planned, maintained and available to support NE missions. To enable and facilitate R&D activities, NE's Idaho Facility Management program maximizes the utility of existing facilities and capabilities through focused sustainment activities and cost-effective rehabilitation.

Concurrent with these efforts to maximize the effectiveness of the established infrastructure, additional investments are being made to achieve further progress in advanced nuclear technologies. NE is currently focusing investments on reestablishing a domestic transient testing capability with the Transient Reactor Test Facility (TREAT) at INL. This capability will enable nuclear energy researchers and technology developers to understand fuel and material performance at the millisecond to second time scale as well as provide a capability to screen advanced concepts, including accident tolerant fuels, which allows for early identification of the limits of performance.

Nuclear Energy University Programs

Like the proposed legislation, DOE has recognized the importance of investing in the next generation of nuclear energy leaders and advancing university-led nuclear innovation. Since 2009, these needs have been addressed primarily through the Nuclear Energy University Programs (NEUP). NEUP engages U.S. colleges and universities to conduct research and development, enhance infrastructure, and support

student education, thereby helping to sustain a world-class nuclear energy and workforce capability. Since 2009, NEUP has awarded over $400 million to 104 colleges and universities in 39 states and the District of Columbia to advance nuclear energy innovation while training the next generation of nuclear engineers and scientists in the United States.

PROPOSED LEGISLATION

The proposed legislation identifies three specific requirements for DOE to address in the areas of High-Performance Computation and Supportive Research, a Versatile Neutron Source, and Enabling Nuclear Energy Innovation. NE programs are currently addressing these three critical areas.

The Consortium for Advanced Simulation of Light Water Reactors (CASL), a DOE Energy Innovation Hub centered at Oak Ridge National Laboratory, was established to provide leading edge modeling and simulation (M&S) capability to improve the performance of currently operating light water reactors. This successful program has now expanded beyond operating reactors to support M&S for SMRs. Additionally, the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program is addressing M&S needs for nuclear fuels and advanced nuclear reactors. As these tools are developed and integrated, NEAMS will be able to provide nuclear technology designers with a truly predictive capability that spans from the fuel pellets to the entire plant to better predict the performance, reliability and economics of advanced nuclear power plants.

With respect to a new versatile neutron source, DOE is evaluating the potential need for a new research reactor capability. To support the development of advanced reactor technology options, the Department has under taken a study to determine the needs of the advanced nuclear reactor community and to develop options, including the key features and timing for a possible advanced test or demonstration reactor to support research, development and demonstration and eventual commercialization of advanced reactor systems. This study, being conducted with the assistance of industry, universities, and the National Laboratories, has included outreach and meetings with key stakeholders. The Nuclear Reactor Technology Subcommittee of the Nuclear Energy Advisory Committee (NEAC) has provided input, advice, and oversight to the process being used to conduct the study. The study will also include an examination of siting requirements, licensing options, international capabilities/partnering opportunities, human capital development, and U.S. leadership. It is our intention to complete the study by April 2016, so that it can be reviewed by the full NEAC during its June 2016 meeting, and ultimately used to inform future actions.

Finally, with respect to enabling nuclear energy innovation, NE identified that improvements can be made to accelerate the innovation of nuclear technologies. To further enable this goal, NE launched the Gateway for Accelerated Innovation in Nuclear (GAIN) during last month's White House Summit on Nuclear Energy. GAIN will provide the nuclear energy community with access to the technical, regulatory, and financial support necessary to move new and advanced nuclear energy technologies toward commercialization while ensuring the continued safe, reliable, and economic operation of the existing nuclear fleet. GAIN will provide the nuclear community with a single point of access to the broad range of resources – people, facilities, materials, and data – across the DOE complex and its

National Lab capabilities. Focused research opportunities and dedicated industry engagement will also be important components of GAIN, ensuring that DOE-sponsored activities are impactful to companies working to realize the full potential of nuclear energy. The response of the nuclear community to the GAIN program announcement has been enthusiastic. GAIN serves as the nuclear energy component of the Clean Energy Investment Center in DOE's Office of Technology Transitions, and INL is serving initially as the GAIN integrator for NE.

CONCLUSION

Nuclear energy is a vital component of the U.S. clean energy strategy. The programs of DOE's Office of Nuclear Energy support many aspects of this important energy source, from reactors, to used fuel management, to infrastructure, and the next generation of engineers and scientists. NE strives to ensure both the current fleet and advanced technologies are available to meet the Nation's energy security and clean energy needs. In a manner that is consistent with the proposed *Nuclear Energy Innovation Capabilities Act,* the Department is performing research and development to move forward advanced nuclear energy technology and is engaging the broader nuclear community, including industry and universities. Additionally, DOE is maintaining and adding to the available infrastructure to enable this work while also working to make it more accessible to support nuclear innovation through the Gateway for Accelerated Innovation in Nuclear.

Chairman Weber, Ranking Member Grayson and members of the Committee, thank you for inviting me to discuss this legislation, and the work that the Department and the Office of Nuclear Energy are currently doing. I would be happy to answer any questions.

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John F. Kotek

Biography

John Kotek serves as the Acting Assistant Secretary for the Office of Nuclear Energy. The Office is responsible for conducting research on current and future nuclear energy systems, maintaining the government's nuclear energy research infrastructure, establishing a path forward for the nation's spent nuclear fuel and high-level nuclear waste management program, and a host of other national priorities.

Prior to his appointment as Principal Deputy Assistant Secretary, John was the Managing Partner of the Boise office of Gallatin Public Affairs, a public affairs and strategic communications consulting company. John advised energy, natural resources and other clients facing complex communication and government relations challenges.

From 2010-2012, John served as Staff Director to the Blue Ribbon Commission on America's Nuclear Future, which recommended a new strategy for managing nuclear waste in the United States. John led the development of the Commission's final report to the Secretary of Energy, engaged in regular communications with Congressional and White House staff, and served as media spokesperson.

From 2003-2006, John was Deputy Manager of the U.S. Department of Energy's (DOE's) Idaho Operations Office. In that role he was responsible for development and management of the Idaho National Laboratory contract and interface with the INL cleanup effort.

Before joining DOE in July 2003, John worked for Argonne National Laboratory as the Generation IV and Nuclear-Hydrogen Programs Manager. He directed Argonne's participation in the *Generation IV* technology roadmapping project, an international effort focused on evaluating and developing the next-generation of nuclear energy systems.

In 2002, John was the American Nuclear Society's Glenn T. Seaborg Congressional Fellow. John served in the Office of Senator Jeff Bingaman (D-NM), Chairman of the Senate Energy and Natural Resources Committee.

John started his career with DOE's Office of Nuclear Energy, Science and Technology. He held several positions during his nine years with DOE-NE, including Associate Director for Technology, Associate Director for Management and Administration, and Chief of Staff.

John holds a Bachelor of Science in Nuclear Engineering from the University of Illinois and a Master of Business Administration from the University of Maryland. He lives in Boise, Idaho with his wife Denise and their three children.

Chairman WEBER. Thank you, Mr. Kotek.

We have been joined by the Ranking Member of the Full Committee, the gentlelady from Texas. You're now recognized for your opening statement, Ms. Johnson.

Ms. JOHNSON. Thank you very much, and I apologize for being late—I knew the vote was coming, and I thought this would follow—on the Nuclear Energy Innovation Capabilities Act, which I am very pleased to cosponsor with you, and I'd like to thank our Acting Assistant Secretary for Nuclear Energy, Mr. John Kotek, for agreeing to be here today on such short notice, and I hope that our friends in the Senate will take away that "Acting" very soon.

As I have noted before, nuclear power plays a vital role in providing our country with clean, reliable energy. I live in an area where there's nuclear energy. Nationally, it produces almost 20 percent of our total electric power and provides almost nine percent of the electricity generated in our great State of Texas, all with essentially no greenhouse gas emissions.

But there currently are technical, economic, and policy challenges that prevent nuclear energy from playing a larger role in enabling our clean energy future. The Nuclear Energy Innovation Capabilities Act takes several positive steps to address these challenges. Implementing the provisions in this bill will help accelerate the development of advanced nuclear energy technologies that are safer, less expensive, more efficient, and produce less waste than the current generation of nuclear reactors.

I look forward to hearing from the distinguished panel that we have here today on any improvements we can make to this legislation to achieve these goals.

I'd like to express my appreciation for the process we followed to put this bill together. Majority and Minority staff worked closely together every step of the way, from engaging stakeholders through the helping to craft and incorporate suggested changes to bill language. This is a great example of what we can achieve when we put politics aside and join forces to address the challenges facing our nation's research enterprise.

I thank all of you for being here, and I yield back, Mr. Chairman. Thank you.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson

House Committee on Science, Space, and Technology
Subcommittee on Energy
"H.R. 4084, the Nuclear Energy Innovation Capabilities Act"
December 3, 2015

Good morning and thank you Mr. Chairman for holding this hearing on the Nuclear Energy Innovation Capabilities Act, which I am very pleased to co-sponsor with you. I would also like to thank the Acting Assistant Secretary for Nuclear Energy, Mr. John Kotek, for agreeing to be here today on such short notice. I hope that our friends in the Senate can finish the task of removing that "Acting" from your title soon – you clearly deserve it.

As I have noted before, nuclear power plays a vital role in providing our country with clean, reliable energy. Nationally, it produces almost 20 percent of our total electric power, and it provides almost 9 percent of the electricity generated in the great state of Texas - all with essentially no greenhouse gas emissions.

But there currently are technical, economic, and policy challenges that prevent nuclear energy from playing a larger role in enabling our clean energy future. The Nuclear Energy Innovation Capabilities Act takes several positive steps to address these challenges. Implementing the provisions in this bill will help accelerate the development of advanced nuclear energy technologies that are safer, less expensive, more efficient, and produce less waste than the current generation of nuclear reactors.

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With that, I yield back.

Chairman WEBER. I want to thank the gentlelady from Texas, and when we opened, I said that I really appreciated you and Chairman Smith's cosponsoring and helping with this bill, so I thank you very much.

Dr. Klein, you are recognized for five minutes.

TESTIMONY OF DR. DALE KLEIN,
ASSOCIATE VICE CHANCELLOR FOR RESEARCH,
UNIVERSITY OF TEXAS

Mr. KLEIN. Thank you. Chairman Smith, Chairman Weber, Members of the Committee, it is a pleasure to appear before you today along with my colleagues to discuss H.R. 4081.

As a former chairman of the Nuclear Regulatory Commission, a Fellow of the American Nuclear Society, and a Research Administrator at a major university, I applaud the committee for introducing this legislation and I hope that it kick-starts a broader effort by all the relevant committees of jurisdiction to review and update federal nuclear energy policy.

While I currently serve as the Associate Vice Chancellor for Research at The University of Texas System and serve on two utility boards, my comments today represent my views, not those of my employer nor the boards on which I serve.

In order to understand the importance of this legislation, it's important to step back and appreciate the larger global context. Currently, there are nearly 2 billion people who still lack basic access to electricity, and many more whose current access is unreliable. Add to that the increasing urbanization of the developing world, with its attendant air quality issues, and finally the need to significantly reduce global carbon emissions, and you have what is perhaps the largest civilian technology infrastructure challenge in world today.

One thing is clear: Any successful response to this challenge will by necessity include a significant role in nuclear energy, and if the United States wants to exert its influence on safety, security, and non-proliferation under which this global growth takes place, it must be a leader in nuclear technology development.

H.R. 4084 is an important first step toward aligning federal nuclear policies with today's realities, and if enacted, I believe would create a more collaborative relationship between the government and the public-private sector to advance nuclear science and public innovation.

It is important to understand, however, that success will require other policy changes that extend beyond the jurisdiction of this committee. For instance, I believe it is inconceivable that any nuclear technology can achieve commercialization without the beneficial scrutiny of the Nuclear Regulatory Commission. I know that many may question my use of the word "beneficial" when you talk about the Nuclear Regulatory Commission, however, its role in protecting the public and the environment are fundamental to any successful nuclear energy technology. The NRC remains the best agency to address these requirements.

I should note that the Committee staff provided me with the July 2015 testimony by NRC Chairman Burns and of Mr. Todd Garvey, Legislative Attorney for the Congressional Research Service, con-

cerning the authority of the NRC to address advanced reactor designs and licensing. After reading their statements I was once again reminded why I became an engineer and not a lawyer. But I believe that there was agreement that the NRC has the authority and is fully capable of providing the review and guidance needed to support innovative technologies. The real question is how do you provide funds to the NRC in order to carry out this activity.

My second point is more of a cautionary note directed to my good friends at the Department of Energy where I encourage them to view this opportunity to change their approach to managing construction projects and public-private partnerships. I would encourage the Committee to consider implementing guidance to Section 7 that would direct the Department to identify governance approaches in addition to contractual mechanisms that would facilitate partnering with the private sector.

My last point is that most nuclear projects today involve some level of international collaboration and foreign involvement. While continued U.S. competitiveness is an important issue, we must also recognize the benefits of collaboration. Therefore, we must be mindful of the restrictions and barriers that we have to international collaborators. I would encourage the Committee to look at activities that would remove barriers with no loss to our national security goals.

I hope that this legislation will provide Congress and the Administration a common ground to rebuild our national security science and technology infrastructure and reinvigorate the collaborative relationship between the government and the private sector.

Thank you very much, and I look forward to your questions

[The prepared statement of Mr. Klein follows:]

Statement by
Dale E. Klein, Ph.D,
Associate Vice Chancellor for Research, University of Texas System
To the U.S. House Committee on Science, Space, and Technology, Subcommittee on Energy
Concerning H.R. 4084, the Nuclear Energy Innovation Capabilities Act
Thursday, December 3, 2015

Mr. Chairman and Members of the Committee, it is a pleasure to appear before you today along with my colleagues to discuss H.R. 4084, the Nuclear Energy Innovation Capabilities Act. As a former chairman of the Nuclear Regulatory Commission, a fellow of the American Nuclear Society, and a research administrator at a major US university, I applaud the committee for introducing this legislation and I hope that it kick starts a broader effort by all the relevant committees of jurisdiction to review and update federal nuclear energy policy.

While I currently serve as the Associate Vice Chancellor for Research at The University of Texas System and serve on two utility boards (Southern Company and Pinnacle West/Arizona Public Service) the comments I make today represent my views and not those of my employer or boards on which I serve.

In order to understand the importance of this legislation, it is important to step back and appreciate the larger global context. While in the US, we are blessed with steady electricity demand, a mature generating and transmission infrastructure, and an abundant supply of inexpensive natural gas, the rest of the world is not similarly endowed. Globally, electricity demand is expected to double between now and 2040, with over 90% of the increase occurring in non-OECD nations. Currently, there are nearly 2 billion people who still lack basic access to electricity, and many more whose current access is unreliable. Add to that the increasing urbanization of the developing world, with its attendant air quality issues, and finally the need to significantly reduce global carbon emissions, and you have what is perhaps the largest civilian technology infrastructure challenge in the history of the world.

One thing is clear, any successful response to this challenge will by necessity include a significant increase in worldwide nuclear energy generating capacity. And if the US wants to exert influence over the safety, security, and non-proliferation norms under which this global growth takes place, it must be a leader in nuclear technology development. We need to face the facts: the US is not the dominant nuclear supplier it once was. Nations such as China, Russia, South Korea, and India are moving

aggressively to develop export oriented nuclear product offerings. If the US is not in a position to compete, we will lose our international influence on key safety and security issues and forgo significant economic and job creation opportunities.

H.R. 4084 is an important first step toward aligning federal nuclear policies with today's realities, and if enacted, I believe would create a more collaborative relationship between government and private sector to advance nuclear science and promote innovation. As nuclear technology development advances into so-called Generation IV designs, it is clear that the government's role must also change. Given current budgetary constraints, I find it difficult to imagine that the federal government will be in a position to spend tens of billions of dollars on 50-50 cost shared development of six types of first-of-its-kind commercial reactor projects.

Conversely, there are some who question the need for government in advancing nuclear science and technology claiming that it is essentially a commercial enterprise. But I challenge them to find any area of modern technology and medicine that does not have at its roots basic and advanced research funded by the government. Many in the science community marked this October as the 25th anniversary of the launch of the Human Genome Project. The Human Genome Project was a 13-year project coordinated by the U.S. Department of Energy and the National Institutes of Health to sequence the 3 billion base pairs that make up human DNA. What is often overlooked is that the enabling legislation for the Project was the Atomic Energy Act of 1954 which authorized the DOE "to conduct research on the biologic effects of ionizing radiation." It was with the support, and I suspect the leeway, of your predecessors on this Committee who authorized the use the Atomic Energy Act to enable one of the most important achievements in modern science. While the government advanced the science, it was the innovators and public-private partnerships that advanced technology and medicine. This has proven to be a successful model for the U.S. system and I believe that same policy approach is enabled in this legislation.

I think the principles that underpin HR 4084 strikes the right balance prioritizing targeted federal investments, such as enhanced modeling and simulation capabilities and a "versatile neutron" scientific user facility that would enable the necessary testing of materials and fuel forms for advanced reactors. The legislation would also create a "National Reactor Innovation Center" to assist private companies in

accessing broadly technological the know-how which exists in the national laboratory system, and provide an accelerated platform for privately funded technology demonstration projects on DOE sites.

It is important to understand, however, that success will require other policy changes that extend beyond the jurisdiction of this committee. For instance, I believe it is inconceivable that any nuclear technology can achieve commercialization without the beneficial scrutiny of the U.S. Nuclear Regulatory Commission (NRC). I know that some may question my use of the term "beneficial" but I believe that defense in depth and adequate protection of people and the environment are fundamental to any successful nuclear energy technology. The NRC remains the best agency to address these requirements. I should note that the Committee staff provided me with the July 2015 testimony of NRC Chairman Burns and of Mr. Todd Garvey, Legislative Attorney for the Congressional Research Service concerning the authority of the NRC to address advanced reactor designs and licensing. After reading their statements I was once again reminded why I became an engineer and not a lawyer. But I believe there was agreement that the NRC has the authority and is fully capable of providing the review and guidance needed to support innovative technologies. The real question is how to provide the NRC with the general funds needed to perform the safety reviews.

My second point is more of a caution directed to my friends at the Department of Energy that they embrace this as an opportunity to change their approach to managing construction projects and public-private partnerships. Frankly, I have been appalled at missteps and poor policies for nuclear projects such as the Mixed Oxide (MOX) facility at Savanah River, the Uranium Processing Facility (UPF) at Oak Ridge, the Hanford Vitrification Plant, and several others. Inadequate planning and poor contract structures are to blame in most cases but application of excessive safety and security requirements that are not risk-informed have crippled and delayed many of these projects as well. Unlike the private sector which is constantly mindful of costs and questioning of changing requirements, there is little to incentivize the DOE project managers to push back. While I applaud the concept of a National Reactor Innovation Center, Congress and the DOE must ensure that the contract structures used minimize uncertainty and project schedule risk. I would encourage the Committee to consider implementing guidance to Section 7 that would direct the Department to identify governance approaches in addition to contractual mechanism that facilitate partnering with the private sector.

My last point is that most nuclear projects these days involve some level of international collaboration and foreign involvement. While continued US nuclear competitiveness is an important issue, we must also recognize the benefits of collaboration with international partners and the potential market for many of these innovative technologies will be overseas. Therefore we must be mindful of the restrictions and barriers that we have to international collaborations. For example, some DOE sites require a minimum of 60-days advance notice before allowing any foreign visitors and overly conservative interpretation of export control regulations makes consulting with foreign nuclear scientists and technologists almost impossible. These barriers are not found in other countries and unless we address this we will continue to lose innovators to those places where they find open and collaborative environments. While not expressly addressed in this legislation, I hope that the Committee may consider guidance that would encourage international collaboration and remove barriers with no loss of our national security goals.

Last month there was a White House summit on nuclear energy convened by Dr. John Holdren, Assistant to the President for Science and Technology. I was gratified that Dr. Holdren embraced, as a matter of Administration policy, "The challenges that we must count on research, development, innovation and public-private partnerships to address....are to reduce capital costs, to maximize safety against malfunction, mistakes, malevolence, and natural disasters, to manage radioactive wastes in ways that are not merely technically sound, but can gain the confidence of the public, and to minimize the pathways by which nuclear energy technology contributes to the proliferation of nuclear weapons." It is my belief, and sincere hope, that this legislation will provide the Congress and the Administration a common ground to rebuild our national nuclear science and technology infrastructure and reinvigorate the collaborative relationship between government and private sector that drives innovation.

Thank you for the opportunity to appear before you today and I look forward to your questions.

Key Points

Dale E. Klein, Ph.D,
Associate Vice Chancellor for Research, University of Texas System

To the U.S. House Committee on Science, Space, and Technology, Subcommittee on Energy
Concerning H.R. 4084, the Nuclear Energy Innovation Capabilities Act
Thursday, December 3, 2015

While I currently serve as the Associate Vice Chancellor for Research at The University of Texas System and serve on two utility boards (Southern Company and Pinnacle West/Arizona Public Service) the comments I make today represent my views and not those of my employer or boards on which I serve.

- Globally, electricity demand is expected to double between now and 2040, with over 90% of the increase occurring in non-OECD nations. Currently, there are nearly 2 billion people who still lack basic access to electricity, and many more whose current access is unreliable. Nuclear energy will play a major role in meeting this global demand. Nations such as China, Russia, South Korea, and India are moving aggressively to develop export-oriented nuclear product offerings. If the US is not in a position to compete, we will lose our international influence on key safety and security issues and forgo significant economic and job creation opportunities.

- H.R. 4084 is an important first step toward aligning federal nuclear policies with today's realities, and, if enacted, I believe would create a more collaborative relationship between government and private sector to advance nuclear science and promote innovation.

- I believe it is unconceivable that any nuclear technology can achieve commercialization without the beneficial scrutiny of the Nuclear Regulatory Commission (NRC). Some may question my use of the term "beneficial" but I believe that defense in depth and adequate protection of people and the environment are fundamental to any successful nuclear energy technology. The NRC remains the best agency to address these requirements.

- I believe that the Department of Energy needs to consider this an opportunity to change their approach to managing construction projects and public-private partnerships. DOE's past performance on nuclear projects big and small does not build confidence. Unlike the private sector, which is constantly mindful of costs and questioning of changing requirements, there is little to incentivize the DOE project managers to push back. The Committee should consider implementing guidance to Section 7 that would direct the Department to identify governance approaches in addition to contractual mechanism that facilitate partnering with the private sector and minimize uncertainty and project schedule risk.

- Most nuclear projects these days involve some level of international collaboration and foreign involvement. While continued US nuclear competitiveness is important issue, we must also recognize the benefits of collaboration with international partners and the potential market for many of these innovative technologies will be overseas. Therefore we must be mindful of the restrictions and barriers that we have to international collaborations. While not expressly addressed in this legislation, I hope that the Committee may consider guidance that would encourage international collaboration and remove barriers.

Dale Klein, Ph.D., P.E.

Dr. Dale E. Klein rejoined The University of Texas System in January of 2011 as Associate Vice Chancellor for Research in the Office of Academic Affairs. In April of 2010, after serving 8 ½ years as a Presidential Appointee, Dr. Klein returned to Texas from Washington, D.C., working at The University of Texas at Austin as the Associate Director of The Energy Institute, Associate Vice President for Research, and a Professor of Mechanical Engineering (Nuclear Program).

Dr. Klein was sworn into the U.S. Nuclear Regulatory Commission in 2006, and was appointed Chairman by President George W. Bush, serving in that role from July 2006 to May 2009. As Chairman, Dr. Klein was the principal executive officer and official spokesman for the NRC, responsible for conducting the administrative, organizational, long-range planning, budgetary, and certain personnel functions of the agency. Additionally, he had the ultimate authority for all NRC functions pertaining to an emergency involving an NRC licensee. The remainder of this term was as Commissioner of the NRC from May 2009 to March 2010.

Before joining the NRC, Dr. Klein served as the Assistant to the Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs. He was appointed to this position by President George W. Bush and confirmed by the Senate in 2001. In this position, he served as the principal staff assistant and advisor to the Secretary of Defense, Deputy Secretary of Defense, and the Under Secretary of Defense for Acquisition, Technology and Logistics for all policy and planning matters related to nuclear weapons and nuclear, chemical, and biological defense programs.

Previously, Dr. Klein served as the Vice-Chancellor for Special Engineering Programs at The University of Texas System and as a professor in the Department of Mechanical Engineering (Nuclear Program) at The University of Texas at Austin. During his tenure at the university, Dr. Klein was Director of the Nuclear Engineering Teaching Laboratory, Deputy Director of the Center for Energy Studies, and Associate Dean for Research and Administration in the College of Engineering.

Honors and awards Dr. Klein has received include the Henry DeWolf Smyth Nuclear Statesman award in 2011, Fellow of the American Society of Mechanical Engineers and the American Nuclear Society, Engineer of the Year for the State of Texas, the University of Missouri Faculty-Alumni Award, and the University of Missouri Honor Award for Distinguished Service in Engineering.

A native of Missouri, Dr. Klein holds a doctorate in nuclear engineering from the University of Missouri-Columbia. He has published more than 100 technical papers and reports, and co-edited one book. He has made more than 400 presentations on energy and has written numerous technical editorials on energy issues that have been published in major newspapers throughout the United States.

He also serves on the Board of the Southern Company and Pinnacle West / Arizona Public Service. Dr. Klein currently serves as the Chairman of the Nuclear Reform Monitoring Committee for the Tokyo Electric Power Company (TEPCO). In addition, he serves on the Committee for Nuclear Power advising the United Arab Emirates (UAE) on their nuclear program.

Chairman WEBER. Thank you, Dr. Klein.

Mr. Rothrock, you're now recognized for five minutes to tell us how to pay for this.

TESTIMONY OF MR. RAY ROTHROCK,
PARTNER EMERITUS, VENROCK

Mr. ROTHROCK. Well, let's start with some big checkbooks.

Good morning, Chairman Weber. Thank you very much for this opportunity, Ranking Member Grayson, Chairman Smith, Ranking Member Johnson and members of the Subcommittee. I really appreciate you all introducing this bill H.R. 4084, Nuclear Energy Innovation Capabilities Act. It's also nice to be among a bunch of fellow Texans. I appreciate that.

This bill comes at a very important time in the history of nuclear power and clean energy, and I'm delighted to share with you today my experiences in the nuclear innovation ecosystem that exist in the United States and how this bill fits in that particular ecosystem.

My journey to this table, I think, started when I was asked to testify how venture capital could assist in the Blue Ribbon Commission on America's Nuclear Future some years ago, which led to my co-producing the movie Pandora's Promise, which ultimately led to a handful of citizens getting together and addressing these problems.

So why nuclear power now? Well, it would be quite irrelevant if not for the fact that there are over 40 nuclear startups in North America now. Please cue the slide.

[Slide]

As we began our journal across the county in the last several years, we discovered a very large group of startup companies, over 40, backed by $1.6 billion of private capital, not government capital, private capital. ThirdWay, based here in Washington, documented this more completely and presented this slide. The needs of these companies are all the same. They need patient investors with deep pockets, modern computational capability, nuclear-qualified laboratory space to prove their designs, and ultimately the approval of the Nuclear Regulatory Commission. The findings of these 40 startups was very exciting to us and also was a surprise to virtually everyone we've talked to, including people in the government.

So the entrepreneurs running these companies have all concluded that there is a need for a new reactor design to address many things that Ranking Member Johnson mentioned about economics, for example. I live and work in the Silicon Valley and have for nearly three decades, and I've witnessed from time to time the way to solve a problem is to get many people working on that problem, many innovators, and in the Silicon Valley we call that many shots on goal. It provides not only competition but it creates speed of solutions, and at the end of the day, we all win. Many shots on goal require lots of ideas, lots of innovators, lots of capital, and I would say that with the 40 startups we have in the United States, we're well on our way to having many shots on goal.

But they can't do it alone. It requires a partnership with the government. For good and obvious reasons, nuclear development by its

very nature and by law requires the government. None of these guys are going to succeed if they try to do this in the Silicon Valley or in a laboratory in New Mexico. It requires nuclear-qualified lab facilities, and this bill talks about bringing some of that capability to them.

The national labs of our country are the finest in the world. I visited many of them, and I've personally spoken to their leaders who are eager to assist, so your bill is well timed.

Also, I want to in the spirit of a good signal to this community congratulate the Department of Energy, the White House, at the White House, the GAIN program, which was just referred to by Mr. Kotek, and all his staff was very well received from the community, and I've met subsequently with many of them. It's very compelling. It's very attractive to the private sector. But I will add this. After nearly 30 years of venture capital and having seen tens of thousands of business plans with very ambitious goals, it is all in the execution, and so I look forward to helping, whatever I can do to help the Department of Energy execute the GAIN program.

There is one—well, I'll skip that. The second signal, operating concepts of nuclear innovation facilities, so I personally went out and surveyed as many of these folks as I could subsequent to being invited to speak here, and a couple of things to point out. This needs to be a very focused program. It needs to operate pretty quickly, so I would recommend a single point of contact for these private companies. They should all submit a work plan that's approved by whatever lab or whatever designated facility is created. They need to be able to pay for it and they need to be able to prove that they can pay for it, which requires teaming with the investors. There is an issue with the way national laboratories charge out some of their overhead. I've talked to several national laboratory directors about this, and I'm sure we can solve that problem, but I would recommend some sort of grant that's a non-cash kind of a grant such as $1 of startup capital, $2 of government capital, that gets into the accounting of it all. I don't mean to get into the—their details there but it's something that needs to get sorted out, otherwise it'll just create more friction in the process.

Intellectual property should belong to the company. The liability should be well understood as everyone goes into this. Everyone needs to be safety-trained on health physics and other safety issues. Information sharing and consultation is very important, and I think embedding the NRC in the process will be a very important element as well.

There's one question that comes to mind, and I'm nearly out of time, but quickly, there is confusion or—well, there is confusion out there. Can a startup company, even if they have the permission to use the DOE facility, can they build a reactor without the approval of the NRC on DOE property? This is a legal issue that was asked and answered years ago, thought resolved, but if you ask people in the system, they are very confused by it.

So I just want to say in conclusion, I support this bill. I hope this and many others that will follow will put the United States back into leadership position that has been suggested here.

I thank you for this opportunity to testify, and we need to hurry. Thank you.

[The prepared statement of Mr. Rothrock follows:]

Summary Testimony of

Ray A. Rothrock
Partner Emeritus, Venrock

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

December 3, 2015

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.

Testimony of

Ray A. Rothrock
Partner Emeritus, Venrock

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.

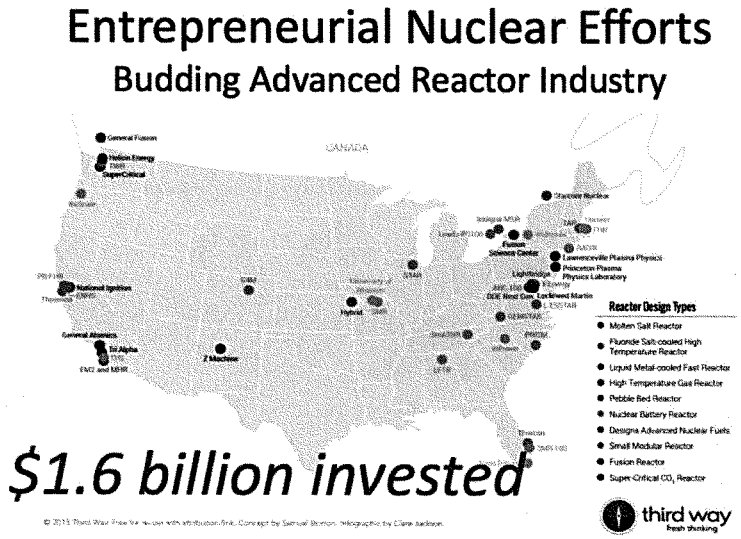
A personal result of the BRC work was that I built an incredible network of nuclear interested entrepreneurs, investors and other folks. I became a co-executive producer of Robert Stone's documentary *Pandora's Promise.* This film was a narrative addressing the large issues of nuclear energy through 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

Chairman WEBER. We need to hurry about this bill, or about voting?

Mr. ROTHROCK. Yes.

Chairman WEBER. Both. Well, we appreciate that, Mr. Rothrock, and we are going to recess. It'll probably take us somewhere around 35, 45 minutes, and then we will be back.

We are recessed.

[Recess.]

Chairman WEBER. Okay. We are reconvened, and if I can find my place in my notes, we'll get started here. Thank you all for waiting for us.

Okay. The Chair's going to recognize himself for five minutes.

Mr. Kotek, you mentioned that the Office of Nuclear Energy is working to address each of the major areas of H.R. 4084 including Section 7, which Mr. Rothrock actually referenced, to enable the private sector to partner with national labs. Do you see any major impediments for DOE to carry out the National Reactor Innovation Center as basically described in Section 7 of the bill?

Mr. KOTEK. Thank you for the question, Mr. Chairman. The timing is actually quite interesting. I mentioned in my testimony, we have the GAIN initiative that we just announced last month. Through that, we're trying, I think, to address some of the things that you're getting at in your bill in terms of providing better access for companies and innovators to the set of tools, capabilities, codes, facilities, et cetera that exist at our national laboratories. So that I think gets at part of it.

Another thing that has been raised with us is the possibility of building privately funded reactors facilities at DOE laboratories, and we're engaged in a process right now where we're working through just what would the specifics of an agreement like that be, and so at this point I can't say for certain that we've got these particular obstacles, but as we go through that process of working through what it would take for a private company to be able to build on a DOE site, I would suggest that we continue to work with your staff to communicate what issues may have arisen and figure out what the resolutions to those things might be.

Chairman WEBER. But you don't see any stumbling blocks to trying to establish this kind of cooperative effort to——

Mr. KOTEK. I think broadly speaking, no, and we're—we've been listening, frankly, to you and to folks like Mr. Rothrock and some of the innovators in nuclear to try to address just the types of challenges you folks are working to address.

Chairman WEBER. And you see the need, right?

Mr. KOTEK. Oh, absolutely.

Chairman WEBER. Good.

Mr. KOTEK. Yes, and that was really part of the motivation. I mean, a lot of the credit for the GAIN initiative comes from this larger conversation we've been having again with your folks in the drafting of this bill but also with Mr. Rothrock and others who want to innovate nuclear and want to get better access to our capabilities.

Chairman WEBER. Good.

And Mr. Rothrock, a question for you. In your testimony, you also pointed out that the U.S. government oversight of nuclear en-

ergy R&D is required by law, and that advanced nuclear startup companies will need some degree of partnership from the federal government, and I think it was you who said, was it one dollar of private money and two dollards of—did you have that backwards? No, that's not the question. So how do you envision the National Reactor Innovation Center and Section 7 of this bill, 4084? How do you envision that center assisting with this effort?

Mr. ROTHROCK. Thank you. I envision it assisting very hands-on. There is—and there is already an existing example, the Mojave Air and Space Port in Mojave, California, 27 private companies, $3 billion of private investment on an old military base run by private enterprise but under the auspices of the FAA. It's not exactly what we're talking about here because at a facility like the national lab, you have people, skilled workers. You have the machines to turn the equipment, to build the equipment, to monitor the safety of it and the health physics. That's what we need. You know, getting a permit to create even a subcritical pile at a facility other than a national lab would be impossible in this country.

So I see it being very direct, hands-on, in the lab with the private-company people and the laboratory people working hand in hand to demonstrate whatever it is they're trying to prove or show, and then also have the NRC embedded in that process too so they will not be surprised by something that's discovered.

Chairman WEBER. Well, that's a good point. We're going to go there with Dr. Klein here in just a second.

Mr. ROTHROCK. Okay.

Chairman WEBER. But the point is that if this were a transportation bill or if this was infrastructure, a building, for example, we would call this a public-private partnership.

Mr. ROTHROCK. Exactly.

Chairman WEBER. And so kind of along those same lines.

And Dr. Klein, moving to you, as former Chairman of the NRC, what R&D capabilities do you think would be necessary for the NRC to help, as Mr. Rothrock just lined out, timely license and advanced reactor design?

Mr. KLEIN. Well, thank you, Mr. Chairman, for the question.

One of the challenges that the NRC has is, they need data to make their safety analysis, so that's why this bill is so important to provide the nuclear infrastructure, to provide data for which the NRC can then make a safety case, and I worry about our country losing its nuclear infrastructure and leadership.

Chairman WEBER. I do too.

Mr. KLEIN. I'll give you a specific example. I've been asked by Terra Power to help guide them on some nuclear licensing activities for their design that Bill Gates is partially supporting. So Terra Power is a design for a fast reactor, and the fuel elements will be in there for longer than we've ever had this done before. So obviously for any kind of licensing, whether it's in China or in the United States, you need some data. In order for Terra Power to do some fuel-quality studies, the only place they could go to do that work is the BOR–60 reactor in Russia, and I think that's a sad state of our nuclear leadership that we do not have the capabilities to do some of those science studies in the United States.

Chairman WEBER. Well, and I appreciate you saying that. So if the NRC was actually involved from the very get-go in watching this data get compiled, would that help in two ways? Would the validity of the data and timeliness so you don't have to go back and reevaluate?

Mr. KLEIN. Right. It would be very beneficial for the NRC to be involved early and often. The NRC has a very good technical staff, and I think they can make decisions, but getting the data and understanding the quality of the data is necessary.

Chairman WEBER. And of course, going back to my discussion with Mr. Rothrock, I would point out that actually the funding for the NRC is actually a public-private partnership in some sense of the word. So thank for you that.

And I'm going to yield to Mr. Grayson.

Mr. GRAYSON. Thank you, Mr. Chairman.

Mr. Rothrock, your testimony focused on shots on goal, the idea that if you let a thousand flowers bloom, some of them will actually bloom, and you also gave us a map that showed startup companies all over the country, dozens of them, focusing on developing fission concepts. How many shots on goal do we have funded by the federal government now in terms of fusion research, making fusion research work, making it economical and a net producer of energy? How many?

Mr. ROTHROCK. There are seven that were on that map that are fusion specifically, and there are two that I'm aware of that are privately financed. The rest are government.

Mr. GRAYSON. Okay. And historically, what are the main investments that we've made in fusion research over time?

Mr. ROTHROCK. Well, there's the ITER project in France, which we've been contributing to, and there is the NIF facility at Livermore, which is a national ignition facility. Those are the two main ones that I'm aware of. There may be some smaller experiments in laboratories and universities but that's it primarily.

Mr. GRAYSON. How much of federal funding for fusion goes to merit-based review of potential proposals that are innovative and high risk, high reward?

Mr. ROTHROCK. I don't know.

Mr. GRAYSON. Is it a large percentage or a small percentage?

Mr. ROTHROCK. Probably—it's probably a small percentage.

Mr. GRAYSON. Do you think it should be more?

Mr. ROTHROCK. Absolutely.

Mr. GRAYSON. Why?

Mr. ROTHROCK. I think we should double our R&D budget everywhere on this topic.

Mr. GRAYSON. Tell me why. Why do you say that?

Mr. ROTHROCK. Because just as you opened with the notion of many shots on goal, you've got to have a lot of ideas tested in the earliest days to find out if they have merit and then they will eventually move forward. If they do have merit, they can seek private funding like many fission projects have and a few fusion projects have and receive that funding.

Mr. GRAYSON. Mr. Kotek, what do you think?

Mr. KOTEK. Thank you, sir. My office, of course, doesn't fund the fusion energy research in DOE. That's a different part of the organization, so I'm not intimately familiar with the funding.

With respect to your specific question about how much goes to innovative concepts, while I don't know off the top of my head, I can certainly work with my colleagues to get you an answer on that.

Mr. GRAYSON. Dr. Klein, do you want to weigh in on this?

Mr. KLEIN. Anything that enhances U.S. leadership in nuclear technology is money well spent. If you look at one of the programs that actually was funded by DOE that was a game changer was the genome project and so the Atomic Energy Act was what let them do that funding, and so we've all seen the results of that. I think the federal government has a responsibility to do high-risk research that then can be turned over to the private sector for innovation.

Mr. GRAYSON. All right. Back to you, Mr. Rothrock. I understand that there was a milestone reached by Tri Alpha Energy recently and that you're familiar with that. Can you explain that, please?

Mr. ROTHROCK. Sure. For fusion reaction to occur, you need to contain the hot plasma and you need to have it at a sufficient temperature that the nuclei will combine. Their milestone event was the containment of plasma at will in a controlled environment, and that is a huge milestone in the plasma universe.

Mr. GRAYSON. So tell us what the next step would be.

Mr. ROTHROCK. To take that same plasma and heat it up to the point where it will ignite and the nuclei will combine, creating the fusion process.

Mr. GRAYSON. Is there a timeline for that?

Mr. ROTHROCK. Yes, probably 5, six years from now.

Mr. GRAYSON. Why so long?

Mr. ROTHROCK. Well, we have—it takes about a year and a half to build the machine and another year and a half to run the data and then probably another year and a half to get it vetted by the world science community. Part of Tri Alpha's efforts recently has been to get the data out into the science world to have it vetted and confirmed that it is in fact good.

Mr. GRAYSON. All right. Let's suppose that happens and it works. What does that mean for the world? What does that mean for America and the world?

Mr. ROTHROCK. Well, it's extraordinary. In Tri Alpha's case, it is a fuel cycle that doesn't produce any neutrons so it is basically the radiation of a hospital, which means you can build very large, high-density electric power plants without the neutron radiation issue that you face with a fission plant. It would be extraordinary.

Mr. GRAYSON. Is that because of the fuel?

Mr. ROTHROCK. Fuel cycle.

Mr. GRAYSON. Do you want to explain that?

Mr. ROTHROCK. The fuel cycle of Tri Alpha is a proton boron reaction, which produces three alpha particles, which are helium with no neutrons. So it uses the soft X-rays to convert to heat to make steam to make electricity. The other fusion cycles, DT, that are being pursued at NIF and other places produce neutrons, and neutrons are very—they make everything radioactive.

Mr. GRAYSON. The deuterium tritium cycle?

Mr. ROTHROCK. DT cycle, yes, sir.

Mr. GRAYSON. Okay. Mr. Kotek, do you want to address the idea of what it would mean for America and the world if we had a successful fusion program?

Mr. KOTEK. Well, certainly as part of the Administration's all-of-the-above energy strategy, we're pursuing fusion research in a wide range of non-emitting technologies, and so any advancements that would make more non-emitting technologies available in the commercial marketplace would be a great thing.

Mr. GRAYSON. All right. Dr. Klein?

Mr. KLEIN. I think if we can make commercial fusion, it'll be a game changer. The question will be, can we do it economically and what are the technical issues to overcome.

Mr. GRAYSON. What do you mean by "game changer"?

Mr. KLEIN. It would be providing electricity to the public at hopefully a reasonable cost with less radiation involved, and an abundant fuel supply.

Mr. GRAYSON. All right. I'll yield back. Thanks.

[The prepared statement of Mr. Grayson appears in Appendix II]

Chairman WEBER. I thank the gentleman for yielding back.

Let's see. Mr. Loudermilk from Georgia, you're recognized for five minutes.

Mr. LOUDERMILK. Thank you, Mr. Chairman, and to the witnesses, thank you for bearing with us during the craziness getting down to vote, and I appreciate you being here. Being from Georgia with the new standards that are coming, if they continue to promulgate, which hopefully they don't, but if they do, we're looking at losing a lot of our coal-fired plants and so we're going to rely more heavily on nuclear, which we do have the first nuclear new reactors going in at Plant Vogtle, which I visited a few months ago with Chairman Weber.

But Dr. Klein, you brought up something that's very interesting to me. I chair the Oversight Subcommittee, and so efficiency and management of these projects is very important, and you brought up in your written testimony, you alluded to it in your verbal testimony, that DOE project managers as compared to the private sector equivalents have little incentive to control project costs, which of course overruns can hinder the advancement of future projects, also because of the lack of funds, and we all want to be very efficient, and I agree with you on that, but on the other hand, in a previous hearing regarding nuclear research and development in the testimony was that there's in some cases too much regulation and that stifles innovation, and so I wondered if you could just opine on where is that balance? What are some of the specifics that you would like for us to implement in Section 7 to strike that balance? And I agree with you, too much regulation or too little oversight can cause waste, too much regulation causes waste as well. If you would, sir?

Mr. KLEIN. Sure. Thank you.

As a recovering regulator from the NRC, one of the things that I think makes the NRC a better regulator is having to deal with the back-fit rule where you do have to make a risk-benefit choice.

I think something like a risk-benefit back-fit rule would help DOE and their project management.

You know, regulators always tend to be conservative. If five guards are good, 10 are even better, so why not do it. So there needs to be a check and balance, and I think on DOE, if they had the incentive to do like a back-fit rule, to do a risk-benefit analysis on the regulatory changes I think it would help the American people.

Mr. LOUDERMILK. Thank you.

Mr. Kotek, would you or Mr. Rothrock also like to weigh in on this at any stage if you have anything to add?

Mr. ROTHROCK. Sure. With regard to the regulation of the—getting through the design cycle and review, an issue that all the startup companies that I've interviewed face is that it takes a lot of money, a long time, and it's not predictable. We have in our government FAA, FDA. They're very dangerous processes, things that can be scary technologically, but we have processes in place to get those through to a point where the public—where they're safe for the public to use and they benefit the public. That system does not exist at the Nuclear Regulatory Commission, and it needs to be addressed, and some of us are working with various people. Chairman Burns is well aware of this. I've spoken to him personally about it. But it is something very important to build a risk-based analysis, technology-neutral analysis rather than prescriptive work.

Mr. LOUDERMILK. Mr. Kotek?

Mr. KOTEK. Thanks. With respect to that particular issue of regulation, one of the things that we're doing in our organization is working with the Nuclear Regulatory Commission to help them as they prepare to receive applications for advanced reactors. So they've got extensive experience dealing with water-cooled reactor technologies but not really with molten salt or metals, et cetera, or gas-cooled reactors. And so we've been working with them over the last several years to develop generic design criteria that could be used in the licensing of advanced reactor types, holding workshops with them, had a very successful one back in September. We'll hold another one early next year to try and help them understand what are the issues that they're going to have to confront as they start receiving some of these advanced reactor designs, and we found that the NRC to be a very willing participant in those discussions under the leadership of Chairman Burns.

Mr. LOUDERMILK. Mr. Chairman, with that, I yield back my remaining 30 seconds.

Chairman WEBER. I thank the gentleman, and my good friend from Texas, Mr. Veasey, is recognized.

Mr. VEASEY. Thank you, Mr. Chairman.

I wanted to just ask you to describe the difference between the process here for bringing a reactor online versus, let's say, in France. I've always heard that sometimes it may be easier in that part of Europe to bring a reactor on to the market versus in America. Can you kind of explain the differences?

Mr. KLEIN. That's a very good question. One of the challenges that we have in the United States is, we have a lot of vendors and a lot of different utilities. France has the advantage of having one vendor, government-owned, one utility, countryowned, and so

therefore they have a standardized plant, and what they do is, they will wait ten years before they'll come out with a new model. So all the advances that they will make, they will bucket those until they come out with their next model. So really, the France technology is developed out of Westinghouse's technology so it's originally rooted in U.S. technology but their standardized plants, one vendor, makes their licensing more simple. I think in the United States, we could do it just as fast once we get the standardized reactors through the design certification and the building process like we're doing for Vogtle 3 and 4.

Mr. VEASEY. So there's no safety issue at all with them bringing them on faster? Because I know that some people will say no, if you bring them on faster, maybe you're giving up safety but you're saying that there's no safety at all, it's just the process is what's different?

Mr. KLEIN. Yeah, it's a preapproved standardized process, no compromises on safety, so their reactors are as safe as ours.

Mr. VEASEY. You know, one of the—you know, we have a nuclear power plant in the part of Texas that I'm from. I live in Fort Worth, and we have one down in Comanche Peak not too far away, and, you know, one of the issues that always comes up is storage of nuclear waste, and of course, you know, you can store on site or move it to a secondary location but of course moving that to a secondary location has always been, you know, controversial whether it's, you know, Yucca, West Texas. Like what do you think are the long-term solutions for dealing with that problem of nuclear waste?

Mr. KLEIN. Well, I visited Comanche Peak several times. That's a very nice facility, safely run. One of my most frustrating activities I had as Chairman of the NRC was the pulling of the Yucca Mountain license application. My job as Chairman was to determine whether it was safe or not. We had a staff of 150 that were marking that technical determination, and they never had the opportunity to finish that. That application was over 8,000 pages, referenced over a million pages of other additional data, and so my frustration part was that as the NRC, as the regulatory body to make the safety analysis of that case, we never had that opportunity. So that's one issue.

At-reactor storage is safe. Having a centralized storage is safe. But we really need as a Nation to move towards a permanent disposition program. It's not a safety issue, it's a political issue.

Mr. VEASEY. So for instance, like how could a plant like, let's say, Comanche Peak or another plant around the country safely store spent fuel?

Mr. KLEIN. You can safely store dry cask storage for over a hundred years so it's not a near-term issue, but it is one in which I think as a Nation we need to progress towards a permanent strategy, and right now we don't have one as a Nation.

Mr. VEASEY. Thank you. Dr. Klein, thank you. I appreciate it.

Mr. Chairman, I yield back my time.

Chairman WEBER. I thank the gentleman.

The gentleman from California is recognized for five minutes.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman, and I'd like to congratulate you, Mr. Chairman, as well as the Chairman of the full Committee on moving forward with this bill, and it's a

very significant issue that we have to deal with, and I don't think we've dealt with it, and we've let ourselves get behind. I was just over in France where they of course get most of their electricity from nuclear energy, and they made those—they made certain technology decisions earlier on that gave them that capability, and they have not had the ups and downs and the problems with being dependent on energy from another country.

About the issues we were just discussing, in terms of storage, do we not have the technological capability now of building nuclear reactors that will not have this leftover waste? And in fact, I've been told by several major companies that it is now within our capability to build nuclear power plants that actually eat the waste that we've had from the past ones. Why are we focused at all on building anything that has leftover waste problem when we have the capability to do something else? The gentleman is shaking his head. Go right ahead.

Mr. ROTHROCK. Yes, we do have that capability. There are a number of advanced reactors in design today by startup companies that I showed earlier that would like to burn up all the spent fuel. There is an enormous amount of energy stored in those pools at these existing reactors, and the site already exists, the fuel pool is there. Why wouldn't we build a reactor just to consume all that fuel?

Mr. ROHRABACHER. How much would it cost—I mean, I was here earlier for—sorry, we had to go out and vote and all these other things. How much would it cost—I noted the billion and a half dollars that's being invested in the private sector in this whole goal. How much would it cost to build one of these? I know about five or six different, you know, high temperature gas-cooled reactor, pebble-based reactor and thorium reactors. They've all been—I like them all. I'm not—I don't have an expert in these like you fellows do. I didn't have to tell which is best. But why are we not—first of all, how much would it cost to build a prototype of one of those small modular reactors that does not have the waste problem?

Mr. ROTHROCK. Boy, I need to be careful here, but we've done that estimate at the company Transatomic and we think it's about five years and $300 million we could demonstrate that capability.

Mr. ROHRABACHER. So five years and $300 million. Would we have a prototype then or just demonstrating the——

Mr. ROTHROCK. Demonstrating the ability to burn spent fuel and to consume it.

Mr. ROHRABACHER. Mr. Chairman, again, if we're going to have a future in nuclear energy, let's not build light water reactors that add more waste and can't handle the major problem that we have when we have the capability of moving forward, but again, building a couple—500 million bucks or something like that to build that prototype, that maybe—is there a way we can facilitate those people in the private sector to move forward with that type of expenditure?

Mr. ROTHROCK. We've had numerous conversations with Idaho National Lab about putting that prototype there, what it would cost, what it would take. Mr. Kotek's department is well aware of some of these ideas. These are early conversations. But we think it's quite doable.

Mr. KOTEK. Yeah, and Congressman, if I could add to that, we certainly are in discussion, have been made aware of companies that are interested in potentially working with the Department of Energy to build prototypes, for example, on DOE sites. We're going through the process now of understanding just what would the contractual relationship need to look like.

With respect to——

Mr. ROHRABACHER. What—yes. Go ahead.

Mr. KOTEK. With respect to the question about waste, I do think it's important to note that you never make all of the waste go away, even if you have a full recycle system where you're recovering all the uranium, plutonium, what we call minor actinide elements, you still have some very long-lived wastes that are left, and so we will always need some sort of a long-term waste isolation capability to support nuclear.

Mr. ROHRABACHER. Yes, but not at the scale.

Mr. KOTEK. I understand. I just wanted to make—I felt I needed to make that clarification.

Mr. ROHRABACHER. If it was—if the scale was smaller, this would not be as great a challenge by definition, and look, we need to move forward, not base—again, light water reactors, they've been around since before I was born. We don't need to move forward and facilitate the production of nuclear reactors based on that when we have other options. I mean, I understand even—is it Lockheed now that has a possibility of a fusion reactor, small fusion reactor? Is that—has anybody looked at that?

Mr. ROTHROCK. They do. It's an experiment at this point, and it's very small.

Mr. ROHRABACHER. Right. And is that real? Is that——

Mr. ROTHROCK. I don't know. I've not——

Mr. ROHRABACHER. Any comments on it? Is it just some kind of a dream that isn't attached to reality there?

Again, there's—we have some new weapon systems right now that we need small modular nuclear reactor in order to make those weapon systems work, and I sure hope that's one part of the formula but the other part of the formula is, our grid. The grid is vulnerable, and if we can have small modular nuclear reactors, we can take the public off the grid. We can have—each community can have their small reactor and you're not going to have this vulnerability that we have now with some solar surge or some nuclear explosion up in the atmosphere. We need to move forward in a rational way, and I'm afraid that we're moving forward with big companies now that basically want to build what they've already built, and I hope that's not the case.

Thank you very much, Mr. Chairman. Thank you for leading the fight to put this bill through and get this passed.

Chairman WEBER. I thank the gentleman. Does that mean you've signed on to our bill?

Mr. ROHRABACHER. I think I already have.

Chairman WEBER. All right. Thank you. I appreciate that.

I want to thank the witnesses for their valuable testimony and the members for their questions. The record shall remain open for two weeks for additional comments and written questions from the members.

This hearing is adjourned.
[Whereupon, at 12:10 p.m., the Subcommittee was adjourned.]

Appendix I

Additional Material for the Record

STATEMENT SUBMITTED BY THE SUBCOMMITTEE ON ENERGY
RANKING MINORITY MEMBER ALAN GRAYSON

OPENING STATEMENT
Ranking Member Alan Grayson

House Committee on Science, Space, and Technology
Subcommittee on Energy
"H.R. 4084, the Nuclear Energy Innovation Capabilities Act"
December 3, 2015

Thank you, Mr. Chairman, for holding this hearing and thank you to the witnesses for being here today.

The bill we are here to discuss, H.R. 4084, aims to provide the tools and resources that scientists and engineers in government, academia, and the U.S. nuclear industry need to once again be the world leader in designing and building advanced nuclear power plants.

These new designs have the potential to be much safer and efficient, while producing less waste. We just need to make sure that we are making the smartest investments we can with our limited resources, and that they are in the best interests of the American people.

And while researching next generation nuclear fission concepts is important, I am also a strong supporter of making much larger investments in fusion energy research. I believe now is the time to build and operate experiments capable of demonstrating that man-made fusion systems can consistently produce far more energy than it takes to fuel them.

So I am looking forward to hearing Mr. Rothrock's perspective on the promise that fusion energy holds and the progress that has been achieved in recent years. Our ultimate goal should be the cleanest and most abundant energy source possible. I believe fusion energy may well be that resource.

I look forward to hearing from our witnesses and working with the Chairmen and Ranking Member to improve this legislation. Thank you and I yield back.

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