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ADVANCING NUCLEAR ENERGY: POWERING THE FUTURE

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

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C O N T E N T S

September 27, 2018

ADVANCING NUCLEAR ENERGY: POWERING THE FUTURE

THURSDAY, SEPTEMBER 27, 2018

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

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Randy Weber [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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Subcommittee on Energy

Advancing Nuclear Energy: Powering the Future

Thursday, September 27, 2018
10:00 a.m.
2318 Rayburn House Office Building

Witnesses

Mr. Edward McGinnis, Principal Deputy Assistant Secretary for Nuclear Energy, U.S. Department of Energy

Mr. Harlan Bowers, President, X-energy

Dr. John Parsons, Co-Chair, MIT Study on the *Future of Nuclear Energy in a Carbon-Constrained World*

Dr. John Wagner, Associate Laboratory Director, Nuclear Science & Technology, Idaho National Laboratory

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

HEARING CHARTER

Thursday, September 27, 2018

TO: Members, Subcommittee on Energy

FROM: Majority Staff, Committee on Science, Space, and Technology

SUBJECT: Subcommittee hearing: "Advancing Nuclear Energy: Powering the Future"

The Subcommittee on Energy will hold a hearing titled *Advancing Nuclear Energy: Powering the Future* on Thursday, September 27, 2018, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of this hearing is to explore future research challenges for advanced nuclear energy technologies in the United States. This hearing will also examine the implementation of S. 97, the Nuclear Energy Innovation Capabilities Act (NEICA).

Witness List

- **Mr. Edward McGinnis**, Principal Deputy Assistant Secretary for Nuclear Energy, U.S. Department of Energy
- **Mr. Harlan Bowers**, President, X-energy
- **Dr. John Parsons**, Co-Chair, MIT Study on the *Future of Nuclear Energy in a Carbon-Constrained World*
- **Dr. John Wagner**, Associate Laboratory Director, Nuclear Science & Technology, Idaho National Laboratory

Staff Contact

For questions related to the hearing, please contact Hillary O'Brien of the Majority Staff at 202-226-8984.

Chairman WEBER. The Subcommittee on Energy will come to order. Without objection, the Chair is authorized to declare recess of the Subcommittee at any time.

So welcome to today's hearing entitled "Advancing Nuclear Energy: Powering the Future." I recognize myself for five minutes for an opening statement.

Today, we're going to hear from a panel of experts on advanced nuclear energy research in the United States and discuss what we can do as a nation to advance this critical area of science. We'll also discuss the implementation of my bill, S. 97, the Nuclear Energy Innovation Capabilities Act.

Nuclear energy, as we all would agree I believe, is a critical part of U.S. energy security. Currently, the 99 nuclear power plants in the United States operating fleet generate about 20 percent of the total electrical output in the United States. Nuclear also provides 60 percent of our emissions-free electricity.

Unfortunately, our commercial nuclear fleet today is made up entirely of light-water nuclear reactor designs using traditional nuclear fuels. Coupled with a long regulatory process, these reactors have become too big, too expensive, and too risky for utilities to undertake. So that means our nuclear fleet is dwindling at the exact moment when we need it to grow. You don't need to look further than this week's news to see the hurdles facing those attempting to build new traditional nuclear plants in this country.

However, advanced nuclear reactors are positioned to change the way nuclear power is sourced, produced, and managed. Decades of early-stage nuclear research conducted at the DOE national labs and renewed investment by private companies are breathing new life into this industry.

As we drafted our nuclear legislation, we met with dozens of these stakeholders working to develop unique and innovative reactor designs. What we heard over and over again was that, despite federal and industry investment, a significant number of research challenges remain for these reactor technologies before they are ready for the commercial license application process. We believe that my bill, S. 97, will help address these challenges. This bill directs DOE to partner with industry to construct and operate reactor prototypes at DOE national labs, and authorizes key research infrastructure needed for next-generation nuclear R&D.

We know that DOE has the expertise to lead in this arena. After all, researchers at Idaho National Laboratory (INL) have designed and constructed 52 pioneering nuclear reactors to date. Our national labs provide a unique environment that safely allows for testing and development of advanced nuclear technology without a burdensome regulatory process that can slow progress to an absolute crawl.

While modeling and simulation can speed research, nuclear fuels and technologies must be validated through direct experimentation in the lab. That's why the cornerstone of this bill is the authorization of construction of the Versatile Neutron Source, a research reactor capable of producing the fast neutrons needed to test so many of those advanced reactor designs.

I look forward to hearing from the Department and from Idaho National Lab today on what steps have been taken to accelerate construction of this critical research facility. In order to maintain our leadership in nuclear power, the United States must continue developing cutting-edge technology right here at home. We cannot afford to miss the economic opportunity provided by the next generation of nuclear technology, and we cannot let our best scientists and engineers go overseas.

Through the implementation of S. 97, we will also strengthen America's ability to influence security and proliferation standards around the world as more and more developing nations look to nuclear energy to help grow their economies. I believe that with their diverse size and power capabilities, advanced nuclear reactors could also bring clean, affordable power to the most remote areas of the world. We have a responsibility to make sure that these reactors are safe and reliable.

I want to thank Ranking Member Johnson and Chairman Smith for their years of leadership in advocating for nuclear energy R&D, and for helping to get our bill to the President's desk. As always, I'm very grateful for the opportunity to work alongside my Science Committee colleagues and Senate counterparts to prioritize fundamental research that will support nuclear innovation while keeping Americans safe, independent, and globally competitive.

Today, we will also hear about the next steps for nuclear R&D. Whether it's focusing on fuels research or expanding lab capabilities, there will be more work to do to ensure we encourage innovation and make smart investments with Americans' tax dollars. I hope we can continue to work together on these issues in the years ahead.

I want to thank the witnesses in advance for their testimony, and I'm looking forward to a productive discussion about how to best take advantage of this exciting and pivotal moment for advanced nuclear technology in the United States.

[The prepared statement of Chairman Weber follows:]

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

For Immediate Release
September 27, 2018

Media Contacts: Heather Vaughan, Bridget Dunn
(202) 225-6371

Statement by Chairman Randy Weber (R-Texas)

Advancing Nuclear Energy: Powering the Future

Chairman Weber: Today, we will hear from a panel of experts on advanced nuclear energy research in the United States and discuss what we can do as a nation to advance this critical area of science. We'll also discuss the implementation of my bill, S. 97, the Nuclear Energy Innovation Capabilities Act.

Nuclear energy is a critical part of U.S. energy security. Currently, the 99 nuclear power plants in the U.S. operating fleet generate 20 percent of the total U.S. electrical output. Nuclear also provides 60 percent of our emissions-free electricity.

Unfortunately, our commercial nuclear fleet today is made up entirely of light-water nuclear reactor designs using traditional nuclear fuels. Coupled with a long regulatory process, these reactors have become too big, too expensive, and too risky for utilities to undertake.

That means our nuclear fleet is dwindling at the exact moment when we need it to grow. You don't need to look further than this week's news to see the hurdles facing those attempting to build new traditional nuclear plants in this country.

However, advanced nuclear reactors are positioned to change the way nuclear power is sourced, produced, and managed. Decades of early-stage nuclear research conducted at the DOE national labs and renewed investment by private companies are breathing new life into this industry.

As we drafted our nuclear legislation, we met with dozens of these stakeholders working to develop unique and innovative reactor designs. What we heard over and over was that, despite federal and industry investment, a significant number of research challenges remain for these reactor technologies before they are ready for the commercial license application process.

I believe that my bill, S. 97, will help address these challenges.

This bill directs DOE to partner with industry to construct and operate reactor prototypes at DOE national labs, and authorizes key research infrastructure needed for next generation nuclear R&D.

We know that DOE has the expertise to lead in this arena. After all, researchers at Idaho National Laboratory (INL) have designed and constructed 52 pioneering nuclear reactors to date. Our national labs provide a unique environment that safely allows for testing and development of advanced nuclear technology—without a burdensome regulatory process that can slow progress to a crawl.

While modeling and simulation can speed research, nuclear fuels and technologies must be validated through direct experimentation in the lab. That's why the cornerstone of my bill is the authorization of construction of the Versatile Neutron Source, a research reactor capable of producing the fast neutrons needed to test many advanced reactor designs.

I look forward to hearing from the Department, and from Idaho National Lab today, on what steps have been taken to accelerate construction of this critical research facility.

In order to maintain our leadership in nuclear power, the United States must continue developing cutting edge technology here at home. We cannot afford to miss the economic opportunity provided by next generation nuclear technology, and we can't let our best scientists and engineers go overseas.

Through the implementation of S. 97, we will also strengthen America's ability to influence security and proliferation standards around the world as more developing nations look to nuclear energy to grow their economies. I believe that with their diverse size and power capabilities, advanced nuclear reactors could also bring clean, affordable, power to the most remote areas of the world. We have a responsibility to make sure those reactors are safe and reliable.

I want to thank Ranking Member Johnson and Chairman Smith for their years of leadership in advocating for nuclear energy R&D, and for helping to get our bill to the President's desk. As always, I'm grateful for the opportunity to work alongside my Science Committee colleagues and Senate counterparts to prioritize fundamental research that will support nuclear innovation and keep America safe, independent, and globally competitive.

Today, we'll also hear about the next steps for nuclear R&D. Whether it's focusing on fuels research or expanding lab capabilities, there will be more work to do to ensure we encourage innovation and make smart investments with American tax dollars. I hope we can continue to work together on this issue in the years ahead.

I want to thank our witnesses for their testimony, and I'm looking forward to a productive discussion about how to best take advantage of this exciting and pivotal moment for advanced nuclear technology in the United States.

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Chairman WEBER. I now recognize the Ranking Member.

Mr. VEASEY. Mr. Chairman, thank you very much for holding this hearing, and I really want to thank the panelists, too. We have an esteemed group of panelists that have joined us this morning to talk about a very important subject, and that is the future of an advanced nuclear industry, an industry that may well be a player in realizing our goal of a less-carbon-energy future.

Historically, nuclear energy has faced a number of challenges, including high costs, long construction times, and safety concerns. However, in recent years, new design concepts and technologies have emerged with a focus on addressing these and other common concerns with nuclear energy.

Advanced nuclear reactor designs have a number of benefits over the current generation of nuclear reactors. They incorporate passive safety features that prevent accidents due to human error. They have much lower waste and use nuclear fuel much more efficiently, and they can be manufactured in factories instead of onsite, reducing costs and shortening construction times.

These new designs could disrupt the U.S. energy portfolio, but for that to happen, we need to make the right investments, and that's why I'm pleased that Democratic and Republican Members of Congress came together earlier this month to pass the Nuclear Energy Innovation Capabilities Act. This bipartisan bill will provide the tools and resources that our scientists and engineers in government, academia, and industry need for us to be the world leader in producing the next generation of nuclear power plant.

This bill authorizes a new user facility that researchers and entrepreneurs will be able to use to test and develop new fuels and materials for novel nuclear reactor designs. It also supports investments in high-performance computing to help accelerate R&D of advanced nuclear reactors without the need for costly and premature investments in physical infrastructure.

And lastly, this bill authorizes a cost-share program with industry to help offset the substantial price of licensing these first-of-a-kind reactors with the Nuclear Regulatory Commission, which is currently considered to be a major barrier to ultimately deploying these advanced technologies.

Beyond the implementation of this bill, I'm looking forward to the testimony of all of our witnesses here today to discuss other issues and ideas that Congress should consider as we aim to accelerate the development of the advanced nuclear industry. I'm especially interested in hearing from Dr. Parsons, who brings a unique big-picture view of the challenges that the industry is currently facing, as well as the potential for advanced nuclear energy to enable our clean-energy future.

And thank you, Mr. Chairman, and I want to yield back the balance of my time.

[The prepared statement of Mr. Veasey follows:]

<u>OPENING STATEMENT</u>
Ranking Member Marc Veasey (D-TX)
of the Subcommittee on Energy

House Committee on Science, Space, and Technology
Subcommittee on Energy
"Advancing Nuclear Energy: Powering the Future"
September 27, 2018

Thank you, Mr. Chairman, for holding this hearing and thank you to this panel of expert witnesses for being here today. We are here to discuss the future of the advanced nuclear industry, an industry that may well be an essential player in realizing our goal of a carbon-free energy future.

Historically, the nuclear energy industry has faced a number of challenges including high costs, long construction times, and safety concerns. However, in recent years, new design concepts and technologies have emerged with a focus on addressing these and other common concerns with nuclear energy.

Advanced nuclear reactor designs have a number of benefits over the current generation of nuclear reactors. They incorporate passive safety features that prevent accidents due to human error. They have much lower waste, and use nuclear fuel more efficiently. And they can be manufactured in factories instead of on-site, reducing costs and shortening construction times. These new designs could disrupt the U.S. energy portfolio.

But for that to happen, we need to make the right investments. That's why I am pleased that Democratic and Republican members of Congress came together earlier this month to pass the Nuclear Energy Innovation Capabilities Act. This bipartisan bill will help provide the tools and resources that our scientists and engineers in government, academia, and industry need for us to be the world leader in producing the next generation of nuclear power plants. This bill authorizes a new user facility that researchers and entrepreneurs will be able to use to test and develop new fuels and materials for novel nuclear reactor designs. It also supports investments in high performance computing to help accelerate R&D of advanced nuclear reactors, without the need for costly and premature investments in physical infrastructure. Lastly, this bill authorizes a cost-share program with industry to help offset the substantial price of licensing these first-of-a-kind reactors with the Nuclear Regulatory Commission, which is currently considered to be a major barrier to ultimately deploying these advanced technologies.

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Thank you, Mr. Chairman, and I yield back the remainder of my time.

Chairman WEBER. Thank you. I'm going to make the next introduction for the next opening statement, but before I do, I want to exercise a personal privilege. The gentleman from Texas that I'm about to introduce is going to be leaving us at the end of this session, and I want to say that he has been a leader among leaders. He has been an absolute brilliant Chairman on more than one committee. He's thoughtful, he's focused, he's been good for America. Please help me in congratulating Chairman Lamar Smith.

[Applause.]

Chairman SMITH. Thank you, Mr. Chairman. That was not expected.

Chairman WEBER. Well, I haven't recognized you yet.

Chairman SMITH. And I appreciate your spreading those nice rumors. You've set a high standard, and I just have to come part way to achieving those, but many, many thanks.

Also, thanks to the witnesses for taking the time to be here as well.

Today, we will hear about the implementation of Science Committee legislation, S. 97, the Nuclear Energy Innovation Capabilities Act, which just two weeks ago unanimously cleared the House for the President's signature. Nuclear fission has been a proven source of safe and emission-free energy for over half a century. As this Committee has repeatedly heard, advanced nuclear energy technology is the best opportunity to make reliable, safe, and emission-free power available throughout the modern and developing world. This new nuclear power technology represents one of the most promising areas for growth and innovation, increasing economic prosperity and lowering the cost of electricity over time.

Because of technical challenges and the high regulatory costs associated with licensing commercial reactors, the DOE national laboratory system plays an important role in supporting nuclear innovation. National labs can host critical research infrastructure, while DOE researchers can investigate the fundamental scientific questions that are key to the development of next-generation nuclear fuels and reactor designs. This approach maximizes the impact of federal research dollars and facilitates the development of a wide variety of nuclear technologies.

The Science Committee's legislation, S. 97, prioritizes infrastructure and early-stage nuclear R&D. The bill leverages DOE's state-of-the-art supercomputers to accelerate the development of advanced reactors. It also creates a reliable mechanism for the private sector to partner with DOE labs. This allows industry to build prototype reactors at DOE sites and creates another pathway for American nuclear entrepreneurs to move innovative reactor technology to market. Most importantly, the bill authorizes construction of a research reactor—or Versatile Neutron Source—at a DOE site. The safe development of advanced nuclear technology at DOE sites will provide access to DOE resources and expertise and fast-track the regulatory process.

After four years of bipartisan collaboration, I'd like to thank my colleagues, particularly Energy Subcommittee Chairman Randy Weber, Ranking Member Marc Veasey, and Science Committee Ranking Member Eddie Bernice Johnson, for their initiative on this subject.

It is critical that we develop the next generation of nuclear reactors here at home. Our witnesses today can provide guidance on the next steps Congress should take to ensure American innovators have the tools they need to develop this groundbreaking technology.

I look forward to hearing about the ways in which DOE and the national labs plan to implement this legislation, and how we can continue to build on the history of American leadership in nuclear power.

Thank you, Mr. Chairman, and yield back.

[The prepared statement of Chairman Smith follows:]

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

For Immediate Release
September 27, 2018

Media Contacts: Heather Vaughan, Bridget Dunn
(202) 225-6371

Statement by Chairman Lamar Smith (R-Texas)

Advancing Nuclear Energy: Powering the Future

Chairman Smith: Thank you, Mr. Chairman, and thanks to our witnesses for being here.

Today we will hear about the implementation of Science Committee legislation, S. 97, the Nuclear Energy Innovation Capabilities Act, which just two weeks ago unanimously cleared the House for the President's signature.

Nuclear fission has been a proven source of safe and emission-free energy for over half a century.

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It is critical that we develop the next generation of nuclear reactors here at home. Our witnesses today can provide guidance on the next steps Congress should take to ensure American innovators have the tools they need to develop this groundbreaking technology.

I look forward to hearing about the ways in which DOE and the national labs plan to implement this legislation, and how we can continue to build on the history of American leadership in nuclear power.

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[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson (D-TX)

House Committee on Science, Space, and Technology
Subcommittee on Energy
"Advancing Nuclear Energy: Powering the Future"
September 27, 2018

Good morning and thank you Mr. Chairman for holding this hearing on the development of advanced nuclear energy technologies and the implementation of the Nuclear Energy Innovation Capabilities Act. This bill, which I was very pleased to co-sponsor, passed both the House and Senate with strong bipartisan support, and I hope that it will be signed into law shortly.

Nuclear power plays a major role in providing our country with clean, reliable energy. It produces almost 20 percent of our total electricity generation, including almost 9 percent of the electricity generated in the great state of Texas. Moreover, right now nuclear plants generate over 50 percent of our carbon-free electricity nationwide.

However, current technical, economic, and policy challenges prevent nuclear energy from playing a larger role in developing our clean energy infrastructure. The Nuclear Energy Innovation Capabilities Act takes several positive steps to address these barriers. 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.

But while I am certainly happy that this bill will soon be the law of the land, I know that there are many other policy proposals that merit our consideration as we aim to ensure that these technologies can play an important role in securing our clean energy future.

This is why I am so pleased that we have this distinguished panel here today. I look forward to hearing each of your views on the current status of the advanced nuclear industry, and the steps we need to take to lead the world in developing and ultimately deploying the next generation of nuclear power.

With that, I yield back.

Chairman WEBER. Thank you, Mr. Chairman.

Our first witness today is Mr. Edward McGinnis, the Department of Energy's Principal Deputy Assistant Secretary for the Office of Nuclear Energy. He's from New Orleans. Prior to his current role, he served as the Deputy Assistant Secretary for International Nuclear Energy Policy and Cooperation, which included the role of Steering Group Chairman of the International Framework for Nuclear Energy Cooperation. Mr. McGinnis has also served as a Vice Chairman and a Principal United States Representative to the Generation IV International Forum. Mr. McGinnis has also served as a Senior Advisor and Special Assistant to four Assistant Secretaries and Deputy Administrators for Nonproliferation and National Security at the Department of Energy.

He holds a master's degree from the American University School of International Service and is a graduate of the Kennedy School's Senior Executive Fellows Program, as well as the program for Senior Executives in National and International Security at Harvard University. Welcome, Mr. McGinnis.

Our next witness is Mr. Harlan Bowers. Am I saying that right?

Mr. BOWERS. You are correct.

Chairman WEBER. Okay. I didn't know how to say Harlan—the President of X-energy, a privately held company based in Greenbelt, Maryland. Previously, Mr. Bowers served multiple roles, including the Senior Vice President of Business Development, the Vice President and Program Manager at Stinger Ghaffarian Technologies, or SGT. Much of his background has involved aerospace systems projects with NASA and commercial customers.

Mr. Bowers received a bachelor of science in aerospace and ocean engineering from Virginia Tech and an MBA from the University of Maryland College Park. Welcome, Mr. Bowers.

Our next witness is Dr. John Parsons, the Co-Chair of Massachusetts Institute of Technology, MIT, Study on the "Future of Nuclear Energy in a Carbon-Constrained World," very timely. Additionally, he is the head of the MBA finance track, Co-Director of MIT's CANES Low-Carbon Energy Center, and an affiliate of the MIT Center for Energy and Environmental Policy Research. Previously, he worked as Vice President and Principal at the economics consulting firm CRA International.

Dr. Parsons holds a bachelor of arts in economics from Princeton University and a Ph.D. in economics from Northwestern University. Welcome, Dr. Parsons.

Our final witness is Dr. John—is it Wager? This says Wager but you have an extra N in your name.

Dr. WAGNER. It's Wagner.

Chairman WEBER. It is Wagner. Thank you. I apologize for that. You're the Associate Laboratory Director of Idaho National Lab's Nuclear Science and Technology, NS&T Directorate. His previous roles included Director of Domestic Programs at NS&T and Director of the Technical Integration Office for the DOE Office of Nuclear Energy's Light Water Reactor Sustainability Program at INL. Dr. Wagner initially joined INL as the Chief Scientist at the materials and fuel complex. He is a fellow of the American Nuclear Society and recipient of the 2013 E.O. Lawrence Award. Congratulations. He has authored or coauthored more than 170 referred—is it referred?

Dr. WAGNER. Refereed.

Chairman WEBER. Refereed. Why, that's amazing that they referee that stuff, isn't it? We probably could use some referees up here in Congress. I'm just saying, okay? Refereed journal and conference articles, technical reports, and conference summaries.

Dr. Wagner received his bachelor of science in nuclear engineering from the Missouri University of Science and Technology and master of science and Ph.D. degrees from Pennsylvania State University. Welcome, Dr. Wagner.

I want to say thank you to all of you all for being here, and we're going to start with Mr. McGinnis. And, Mr. McGinnis, you have five minutes. You're recognized to start. Thank you.

TESTIMOMY OF MR. EDWARD MCGINNIS, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. MCGINNIS. Thank you, Mr. Chairman. I greatly appreciate the opportunity to speak before this subcommittee.

Chairman Smith, Subcommittee Chairman Weber, and other Members of the Subcommittee, it is an absolute privilege to be here today, and we want to recognize the leadership of this Subcommittee, of the committee for your important work, including with this legislation.

As a major source of reliable, clean, baseload electricity, nuclear energy is a key asset for the United States. It is in fact an essential element of the nation's diverse energy portfolio, helping to sustain the U.S. economy and support our national goals. A strong domestic nuclear industry enabled by the existing nuclear fleet and enhanced by innovative technology developers is critical to our national security interests as well.

Today, nuclear energy is the third-largest source of domestic electricity generation and is the largest source of clean energy, as you indicated, Mr. Chairman. Besides providing reliable clean baseload electricity, nuclear power plants also provide price stability. That is an important but rarely talked about attribute. Nuclear power plants serve as bedrocks to communities across the country, providing high-paying, skilled generational jobs to almost half a million Americans.

The U.S. nuclear fleet is also a significant contributor to the federal budget and generates $10 billion in federal taxes, $2.2 billion in state taxes each year. These units are drivers of local economies as well, often serving as the largest employer and economic engine of small communities, anchors to communities in fact.

Even with all of these benefits, however, the nuclear energy sector is indeed undergoing a major transformative period of time due to a variety of factors that include changing and very challenging market conditions, an aging fleet of reactors, and an absence of nuclear energy product choices and innovative business/technology deployment models available to customers. In my view, these factors are actually driving the transformative bow wave of highly innovative technologies, one of which is represented here today on this panel, advanced additive manufacturing techniques, and new innovative business models coming out of the U.S. nuclear energy sector.

So what do I mean when I say the nuclear sector lacks product choice? Today, utility customers and communities around the United States, who may be interested in acquiring nuclear energy's long-term clean and reliable source of power for their communities, are faced with a rather startling limited choice of only large or larger reactors. These large reactors can take five to ten years to build before generating revenue from power production. So additionally, many international markets find these gigawatt-class reactors as simply too large for their electricity grids. As long as there are only large and larger reactors, the nuclear energy reactor markets in my view will remain substantially constrained relative to nuclear energy's true market potential.

So what do we do—what do we see happening to respond to this lack of product choice by those who otherwise would very much like to have the unique energy attributes offered by nuclear energy? We see the market response through the emergence of 50-plus U.S. nuclear reactor technology companies, and they are developing these highly, highly innovative small, scalable, flexible, versatile, and financeable nuclear reactors. These innovative concepts include small modular reactors, microreactors, high-temperature gas reactors, molten salt reactors, and even liquid metal fast reactors.

We are not only seeing game-changing and highly disruptive advancements in the U.S. nuclear design space but also in the advanced manufacturing area as well. The ultimate goal with our early-stage advanced manufacturing research and development is to enable the development of innovative processes, such as 3–D printing, that can be applied to nuclear energy technologies, and this is what I call game-changing.

Finally, the U.S. industry is leading multiple advanced nuclear fuels development efforts with some of the design components already in U.S. reactor fleet undergoing testing. These designs offer real potentially substantially improved economics and margins. The advanced fast test reactor is an absolute key test platform that we see will be needed to support this new class, this new bow wave of very disruptive, very promising, and very innovative technologies that are U.S.-developed. So we have a unique opportunity to realize a leapfrogging effect during this inflection moment that we find ourselves in this country with regards to nuclear energy, but it is by no means too late, but it certainly is in the fourth quarter, and this is the time it will be frankly in my view on my watch, on our watch, in the next five to eight years as to whether we do realize the true potential of these exciting new companies, again, like one represented here today.

So thank you very much for the opportunity to testify today.

[The prepared statement of Mr. McGinnis follows:]

Testimony of Edward G. McGinnis
Principal Deputy Assistant Secretary for Nuclear Energy
U.S. Department of Energy
Before the
Committee on Science, Space, and Technology
Subcommittee on Energy
United States House of Representatives

September 27, 2018

Chairman Smith, Ranking Member Johnson, Subcommittee Chairman Weber, Subcommittee Ranking Member Veasey, and Members of the Subcommittee, I am pleased to appear before you today to discuss the very important matter of commercial nuclear energy.

As the major source of reliable clean baseload electricity, nuclear energy is a key asset for the United States. It is an essential element of the Nation's diverse energy portfolio helping to sustain the U.S. economy and support our national goals. A strong domestic nuclear industry enabled by the existing nuclear fleet and enhanced by innovative technology developers is critical to our national security interests as well.

Today, nuclear energy is the third largest source of domestic electricity generation and is the largest source of clean energy. Besides providing reliable clean baseload electricity, nuclear power plants also provide price stability, an important but rarely talked about attribute.

Nuclear power plants serve as bedrocks to communities across the country, providing high-paying, skilled jobs to almost half a million Americans[1]. The U.S. nuclear energy fleet is also a significant contributor to the economy, generating $10 billion in federal taxes, and $2.2 billion in state taxes each year[1]. These units are drivers of local economies as well, often serving as the largest employer and economic engine of small communities.

Even with all of these benefits, the nuclear energy sector is undergoing a major transformative period of time due to a variety of factors that include changing and very challenging market conditions, an aging fleet of reactors, and an absence of nuclear energy product choices and innovative business/technology deployment models available to customers. In my view, these factors are actually driving the transformative bow-wave of highly innovative technologies, advanced additive manufacturing techniques, and new innovative business models coming out of the U.S. nuclear energy sector.

So what do I mean when I say the nuclear sector lacks product choice? Today, utility customers and communities around the United States, who may be interested in acquiring nuclear energy's long-term clean and reliable source of power for their communities, are faced with a rather startling limited choice of only large or larger nuclear reactors designed to produce between 1,000 MWe to 1,500 plus megawatt electric (MWe). These large reactors can take up to10 years to build before generating revenue from power production. Additionally, many international markets find these gigawatt class reactors simply too large for their electricity grids. As long as there are only large and larger reactors, the nuclear energy reactor markets will remain substantially constrained relative to nuclear

[1]https://www.nei.org/resources/fact-sheets/nuclear-by-the-numbers

energy's true market potential.

So what do we see happening to respond to this lack of product choice by those who otherwise would very much like to have the unique energy attributes offered by nuclear energy? We see the market response through the emergence of over 50 U.S. nuclear technology developers who are looking to seize this opportunity by advancing highly innovative small, scalable, flexible, versatile, and more financeable nuclear reactors. These innovative concepts include small modular reactors (SMRs), micro reactors, high temperature gas reactors, molten salt reactors and liquid metal fast reactors.

We are not only seeing game-changing and highly disruptive advancements in the U.S. nuclear reactor design space, but also in the advanced manufacturing area as well. The ultimate goal with our early-stage advanced manufacturing research and development (R&D) is to enable the development of innovative processes, such as 3-D printing, that can be applied to nuclear energy technologies. This is what I call a game-changer. Finally, the U.S. industry is leading multiple advanced nuclear fuels development efforts with some of the design components already in U.S. reactors for testing.

I hope what I have said thus far gives the Subcommittee a sense of the tremendous opportunity facing the United States due to the bow-wave of U.S. advanced nuclear companies, and the historic demand and need for new and innovative nuclear energy products and services. Now I'd like to shift the discussion a bit to discuss the role my office plays in supporting the development of these concepts and how that relates to some key pieces of legislation of interest to this Subcommittee.

Utilizing our greatest strengths, the Department is mobilizing its world-class capabilities, and implementing targeted early-stage R&D partnerships between academia, the national laboratories and the U.S. nuclear industry. Through the Gateway for Accelerated Innovation in Nuclear (GAIN), for example, NE is enabling industry to have more efficient access to DOE's facilities and expertise. Through GAIN, DOE also provides vouchers that direct-fund its laboratories to support the needs of U.S. industry nuclear technology developers through application of their unique experimental, analytical and engineering capabilities.

The support of the Department of Energy and its world-class laboratories is essential to the U.S. nuclear industry as it works to bring forth new innovative technologies and approaches.

The Department is also conducting R&D activities that would be necessary for the development of a versatile advanced fast test reactor. Such a reactor would accelerate innovation in advanced fuels and materials for U.S. nuclear vendors and pave the path to U.S. global leadership in advanced nuclear R&D by reestablishing this capability. Requirements have been developed and an R&D plan has been created. The fiscal year 2019 appropriation of $65 million will help us continue to move forward with this project.

Furthermore, many advanced reactor concepts, including the DOE versatile advanced fast test reactor currently under development, will need high-assay low-enriched uranium (HALEU), for which there is currently no commercially available supply in the world. HALEU is uranium that is enriched between 5 to 20% U-235. NE is very familiar with this issue and is working with the National Nuclear Security Administration (NNSA) to move forward on options for enrichment and spent nuclear fuel recycling that could support both

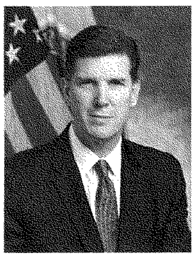
U.S. advanced reactors and other DOE needs.

The Department is also exploring other innovative and collaborative approaches to support our Nation's evolving electricity grid. One such area is our collaborative work with the Office of Energy Efficiency and Renewable Energy on integrated energy systems, also referred to as hybrid energy systems. Optimization of nuclear and variable renewables could be an excellent way to meet clean electricity needs, and it could also prove to be a disruptive step-change improvement for non-electric markets as well. By integrating with variable generation, nuclear power plants can increase operational flexibility and provide process heat for non-electric industrial applications, hydrogen production, or desalination and wastewater treatment; thereby increasing revenue generation and the overall economics of nuclear power.

The Administration is fully committed to nuclear energy as a vital component of our Nation's energy system. I firmly believe that with a focused and sustained collaborative private-public partnership approach, and by working closely and thoughtfully together with key U.S. stakeholders, this subcommittee and all of Congress, we can indeed revive, revitalize, and expand our Nation's nuclear energy sector and restore our global nuclear energy leadership. By leveraging our national laboratory system, and enabling innovative thinking across academia and the private sector, we can support the development of a new and highly innovative class of U.S. advanced nuclear reactors, an innovative and responsive nuclear energy supply chain, and advanced nuclear energy fuel cycle technologies, positioning the U.S. for energy dominance in the 21st century. By taking these actions, we can help ensure that future American generations continue to benefit, as we have, from this emission-free, reliable, and secure power source for our Nation.

Thank you very much and I look forward to answering your questions.

Edward McGinnis, Principal Deputy Assistant Secretary for Nuclear Energy



Edward McGinnis serves as the Principal Deputy 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 current role, Edward McGinnis served as Deputy Assistant Secretary for International Nuclear Energy Policy and Cooperation and was responsible for the Department of Energy's international civilian nuclear energy activities, including international nuclear energy research, development and demonstration cooperation, multilateral nuclear energy cooperation, international nuclear energy policy, international nuclear safety cooperation, and advocacy for US civil nuclear exports and industry.

As part of these responsibilities, Mr. McGinnis served as Steering Group Chairman of the International Framework for Nuclear Energy Cooperation that consists of more than 65 countries and four international organizations. He also served as the Departmental Representative in the US interagency for civil nuclear energy trade and promotion. Moreover, Mr. McGinnis has served as a Vice Chairman and Principal U.S. Representative to the Generation IV International Forum and was responsible for US domestic nuclear fuel assurance matters, including technical oversight activities regarding the United States Enrichment Corporation, uranium inventory management matters, as well as US nuclear energy security matters.

Prior to working in the Office of Nuclear Energy, Mr. McGinnis led a number of other high priority United States Government initiatives at the Department of Energy, including having served as the senior Director for the Office of Global Radiological Threat Reduction where he managed global operations involving the search, recovery, security and disposal of high-risk radiological and nuclear sources in cooperation with over 40 countries, including within the U.S. These activities included recovery of high-risk radiological sources from Iraq, establishment of a Global Radiological Regional Partnership Program, and the first-of-its-kind repatriation of high-risk U.S.-origin plutonium-239 sources. Mr. McGinnis also established and served as the Director of the Nuclear and Radiological Threat Reduction Task Force which was created to carry out a number of key Secretarial national security initiatives, including the development of a global nuclear materials removal and research reactor security study that included the identification of nuclear research reactors throughout the world by level of vulnerability and an action plan to effectively mitigate such vulnerabilities.

Mr. McGinnis also served as senior advisor and special assistant to four Assistant Secretaries and Deputy Administrators for nonproliferation and national security at the Department of Energy where he served as a senior advisor for all aspects of the Department's nonproliferation missions, including nonproliferation research and development, materials protection, control and accounting, and warhead security.

Mr. McGinnis holds a master's degree from The American University's School of International Service in Washington, D.C., and is a graduate of the Kennedy School's Senior Executive Fellows Program as well as the Program for Senior Executives in National and International Security at Harvard University.

Chairman WEBER. Thank you, Mr. McGinnis.
Mr. Bowers, you're recognized for five minutes.

TESTIMONY OF MR. HARLAN BOWERS, PRESIDENT, X-ENERGY

Mr. BOWERS. Thank you, Chairman Weber, Ranking Member Veasey. Thank you for your leadership and that of the Members of the Energy Subcommittee on the important nuclear industry policy issues facing our country today. I have submitted a more detailed written statement and respectfully request that it be included in today's record of the hearing. And with that, I would like to summarize my testimony and respond to any questions that you may have.

My name is Harlan Bowers. Harlan County, Kentucky, was where that comes from. I'm President of X-energy. Our CEO Cam Ghaffarian started this company ten years ago with the altruistic desire to make a difference in the world, to find ways to deliver clean, safe, secure, and affordable energy to the U.S. electrical industry, U.S. industrial process heat users, and the needs of foreign countries.

The Nuclear Energy Innovation Capabilities Act, or NEICA, and the other advanced nuclear energy bills that are being considered in Congress genuinely address the obstacles that our industry face. Again, we appreciate your support and leadership.

Today, our company is focused on two products, a 75 megawatt electric high-temperature gas-cooled pebble-bed reactor—we call it an HTGR—and the complementary uranium fuel. The fuel is based on the Department of Energy's investment of almost $300 million in something called tri-structural isotropic or TRISO particles.

Over the last nine years, we've continuously evolved our reactor concept, focusing on defining a design that employs well-understood technologies, delivers electricity at rates that are competitive with fossil fuel sources, and can be readily licensed by the NRC. X-energy is working to complete our first demonstration reactor by the mid- to late 2020s. To achieve this goal, we need industry, Department of Energy, the national labs, the NRC, the investment community, and Congress to work together collectively if we're to meet the challenges in front of us.

Our success at X-energy is advanced by the programs and the entities that are supported in your legislation. Let me give you some examples. Private-public partnerships, these are needed for successful demonstration of advanced reactors. Fortunately, the Office of Nuclear Energy at the DOE, with Congressional funding, has stepped up their support of advanced reactors, and we thank Deputy Assistant Secretary Ed McGinnis and his team for the work that they have done and the leadership they've provided.

Through the award of competitively selected cooperative agreements, X-energy has been able to accelerate our progress against a number of key objectives. Of course, investing in nuclear is not for the faint of heart. Several hundred million dollars will be required to complete our design and the licensing through the NRC. That is why we're pleased to see the cost-share portion and provision of the NEICA legislation. These provisions are critical to the success of our industry.

National labs play a vital role in supporting nuclear industry competitiveness and advanced reactor development as well. X-energy has extensive partnerships with the Idaho National Lab and the Oak Ridge National Lab. For example, at ORNL onsite, X-energy has established a TRISO fuel fabrication facility. This collaboration represents one of the most important missions of the labs. The lab performs research to identify gamechanging technologies and then partner with industry to advance that technology into the marketplace, thus making the United States more competitive and ensuring a technological advantage for U.S. companies.

Another essential voice is the Nuclear Regulatory Commission. The NRC recognizes at the highest levels that they must modernize and improve the way that they historically carry out their regulatory mandate. Initiatives such as the licensing modernization program will enable advanced reactors to be licensed more efficiently. We applaud the efforts undertaken to date and look forward to engaging with the NRC in that licensing process.

In closing, let me go back to our end goal, to build and demonstrate an advanced reactor and create a new industry by the mid- to late 2020s. To accomplish this, we must have high-assay low-enriched uranium available by 2023 in order to manufacture the fuel needed to fuel those advanced reactors by 2025. This means we need to construct and license new fabrication facilities for fuel by the early 2020s. Therefore, to accomplish all this, DOE action and supportive bills such as NEICA in fiscal year 2019 is absolutely critical to make our collective goal a reality.

X-energy is proud to join with the outstanding leadership of this committee and executing upon the policies that will allow the United States to reclaim our global leadership position in this great American-born nuclear industry.

For energy security, for national security, and to ensure the highest standards of safety throughout the world, we had X-energy stand ready to continue to work with this committee and with the Congress in this grand endeavor.

With that, I will conclude, and I'll support any questions that you may have. Thanks very much.

[The prepared statement of Mr. Bowers follows:]

X energy

Summary of Statement for Harlan W. Bowers
President, X Energy, LLC
Before the Committee on Science, Space & Technology,
Subcommittee on Energy
For Hearing on Advancing Nuclear Energy: Powering the Future
September 27, 2018

X Energy, LLC (X-energy) was founded almost 10 years ago on the altruistic desire to make a difference in the world – to find ways to deliver clean, safe, secure, and affordable energy to the U.S. electrical industry and serve the needs of foreign countries.

X-energy is focused on two products – a 75 MWe high temperature gas-cooled (HTGR) pebble bed reactor and the complementary uranium fuel, based on the DOE's investment in tristructural isotropic (TRISO) fuel pebbles. We are working to complete our first demonstration reactor by the mid-to-late 2020s.

We have continuously evolved our Generation IV advanced reactor concept, focused on defining a design that employs mature technologies, delivers electricity at competitive rates, and can be readily licensed by the U.S. Nuclear Regulatory Commission (NRC).

Private/Public Partnerships: Solid private/public partnerships are needed for advanced nuclear success. Several hundred million dollars will be required to complete our design and secure a license from the NRC. That is why we were pleased to see the cost-share provision in the Nuclear Energy Innovation Capabilities Act (NEICA) legislation.

National Labs: National Labs also play a vital role in supporting nuclear industry competitiveness and advanced reactor deployment. X-energy has extensive partnerships with Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL). At ORNL, through our Cooperative Agreement, X-energy has established a TRISO fuel fabrication facility to be utilized to begin the fuel qualification process.

NRC: The NRC recognizes at the highest levels that they must modernize and improve the way they have historically carried out their regulatory mandate. Toward that end goal, the NRC, DOE, Southern Company, and the industry, through the Nuclear Energy Institute, have been working together on the Licensing Modernization Program – a joint effort to define a new licensing framework that enables advanced reactors to be licensed more efficiently. We have been very supportive of this effort.

International Competition: We are in an energy race to get U.S. advanced reactors to market. The Chinese and others are already marketing their advanced reactors to the Middle East, Africa and European countries.

Continued investment is critical. We ask that Congress continue to focus on the end goal of getting advanced reactors deployed by 2025-2030. To accomplish that, program funding over the next two years becomes absolutely critical to making deployment a reality. To qualify and fuel these reactors, we must have HALEU available by 2023 in order to manufacture fuel by 2025 for the initial set of advanced reactors. This means we must construct and license the appropriate fuel fabrication facilities in the early 2020s.

At X-energy we are proud to join with the outstanding leadership of this Committee in executing upon the policies that will allow the U.S. to *reclaim* its global leadership position in this great American born industry, for our own energy and national security, and to ensure the highest standards for safety for our world.

Xenergy

Prepared Statement of Harlan W. Bowers
President, X Energy, LLC
Before the Committee on Science, Space & Technology,
Subcommittee on Energy
Hearing on Advancing Nuclear Energy: Powering the Future
September 27, 2018

Thank you, Chairman Weber and Ranking Member Veasey for your leadership and to members of the Energy Subcommittee for this opportunity.

X Energy, LLC (X-energy) was founded almost 10 years ago on the altruistic desire to make a difference in the world – to find ways to deliver clean, safe, secure, and affordable energy to the U.S. electrical industry and serve the needs of foreign countries.

We express our sincere appreciation for the leadership shown by this Committee, the Congress, and the U.S. Department of Energy (DOE) for prioritizing the deployment of advanced nuclear technology. The Nuclear Energy Innovation Capabilities Act (NEICA) and the other advanced nuclear energy bills currently being considered in Congress are genuinely trying to address the obstacles that our industry face.

Today, our company is focused on two products – a 75 MWe high temperature gas-cooled (HTGR) pebble bed reactor and the complementary uranium fuel, based on the DOE's investment in something called tristructural isotropic, or TRISO fuel pebbles.

We have continuously evolved our Generation IV advanced reactor concept – focused on defining a design that employs mature technologies, delivers electricity at competitive rates, and can be readily licensed by the U.S. Nuclear Regulatory Commission (NRC). X-energy is working to complete our first demonstration reactor by the mid-to-late 2020s. To achieve this goal, we need partnerships– partnerships that encourage industry, the DOE, the National Labs, the NRC, the investment community, and Congress to work collectively to help us meet the challenges before us.

We've been able to complete almost 50 percent of our Xe-100 reactor conceptual design to date. To ensure a timely reactor demonstration, we have taken responsibility for ensuring the nuclear fuel will be available concurrent with the reactor. The TRISO fuel is recognized by the DOE and the NRC as a safer fuel form, because the sand-sized grains of uranium are encased in graphite and silicon carbide, retaining the radionuclides and fission gases that form during the reaction. This means that the nuclear plant safety case is based strongly on the fuel design and performance, making the need for a large, complex, and expensive containment structure over the reactor completely unnecessary. The DOE has spent over $300M utilizing the national R&D infrastructure to test and characterize this fuel. We continue that effort today.

The National Labs also play a vital role in supporting nuclear industry competitiveness and advanced reactor deployment. X-energy has partnered with Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL). At Oak Ridge, our teams work side-by-side to understand the research performed during the previous decade, to replicate their successes, and then to expand the laboratory scale capability to using equipment and techniques needed at a commercial level – the planning necessary to produce hundreds of thousands of fuel forms annually.

At ORNL, through our Cooperative Agreement, X-energy has established a TRISO fuel fabrication facility, with commercial-scale equipment, for the purpose of finalizing our commercial techniques, methods, and processes. We are currently producing particles and pebbles. Next year we will be utilizing HALEU. This collaboration represents one of the most important missions of our National Labs – to perform research, to identify and quantify game-changing technologies, then support their deployment into industry, whereby making the U.S more competitive and ensuring a technological advantage for U.S. companies and workers.

Private/public partnerships are needed for advanced nuclear success. The Office of Nuclear Energy at the DOE, with Congressional funding, has supported our industry. We thank Deputy Assistant Secretary Ed McGinnis and his team for their leadership. Through the award of competitively selected cooperative agreements to X-energy – one for $53M and a second awarded this year, currently funded to $10M – we can more quickly advance our reactor design and complete design and licensing of a commercial-scale TRISO fuel fabrication facility. These, and other similar awards propel forward the entire advanced reactor industry. In particular, our TRISO-X fabrication facility will be able to fabricate using uranium at higher enrichment levels than is available commercially today and supply fuel to all HTGRs and several other advanced reactor designs in development.

But investing in nuclear is not for the faint of heart. Several hundred million dollars will be required to complete our reactor design and secure a license from the NRC. That is why we were pleased to see the cost-share provision in the NEICA legislation. The "first customer" will not commit to purchase until we are able to build a first-of-a kind reactor and demonstrate economic performance. Consequently, it is very difficult to obtain typical financing for the development of the first reactor.

Additionally, the construction of our fuel fabrication facility will require $100-200M. We have engaged with investment banks to understand their requirements on risk and return. We intend to pursue every mechanism available to ensure we are successful – additional DOE cooperative agreements, loan guarantee program backing, and investment by other entrepreneurs with a vision similar to our Founder and Chief Executive Officer, Dr. Kam

Ghaffarian – to assemble the funding necessary to be first to market with an advanced reactor, and to compete globally in an industry that must reinvent itself to be competitive.

Another essential voice is the NRC. The NRC recognizes at the highest levels that they must reinvent and modernize the ways they have historically carried out their regulatory mandate. The NRC must broaden their skill sets to understand multiple advanced reactor technologies. They must streamline their analysis processes to accomplish their reviews quicker, in a way that facilitates nuclear plant investment. It means adopting methods that define what acceptable safety is, as opposed to prescribing the specific design techniques the developer must employ to satisfy NRC safety requirements.

After decades of licensing the same light water technology many times, redirecting their licensing approach is not an easy task to accomplish. The NRC, DOE, Southern Company, and the industry, through the Nuclear Energy Institute, have been working together on the Licensing Modernization Program – a joint effort to define a new licensing framework that enables advanced reactors to be licensed more efficiently. X-energy applauds the efforts undertaken to date and looks forward to engaging with the NRC staff in the licensing process.

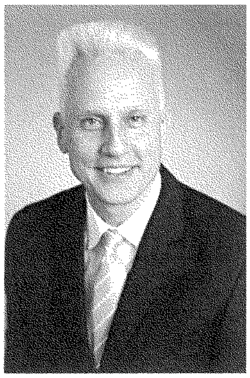
Internationally, X-energy has been engaged, with the support of the U.S. Department of Commerce and the DOE, in discussions with Poland, Indonesia, Saudi Arabia, and the Kingdom of Jordan. All are intrigued by the attributes that an HTGR brings – passive safety, cost-competitive electricity generation in a smaller package, and the ability to produce very high temperature steam for industrial processes, including desalination. These smaller reactors are particulary suitable for power in remote communities as well as providing load-following capabilities to complement renewable energy sources. Each country expressed their interest in creating a peaceful, domestic nuclear industry and desired partners to help them. That's fine, but we are interested in promoting our Xe-100 design, developed domestically using a U.S. supply chain. Who is our strongest competition in these markets? The Chinese, who have completed a pebble bed HTGR plant for commercial electricity generation. They are crowding out U.S. leadership in international nuclear markets, replacing U.S. products with theirs through innovative financing and a government-funded design. They are, unfortunately, 5-8 years ahead of us.

One of the sections not always focused on in NEICA is on modeling and simulation. This is vital to the success of the advanced reactor community and is a capability residing in the National Labs. For example, the neutronics codes for simulating reactor operation that are familiar to the NRC today are for light water reactors. Most advanced reactors will have to develop new codes. In X-energy's case, we developed, in collaboration with INL and ORNL, a neutronics roadmap to outline what is necessary for a robust neutronics code development. This is a $10-12M effort and the National Labs are best suited to address this type of initiative. The codes they create will then be used by industry and the NRC to verify safe design.

Continued investment is critical. Congress needs to continue to focus on the end goal of getting advanced reactors deployed by 2025-2030. To accomplish that, program funding over the next two years becomes absolutely critical to making deployment a reality.

At X-energy we are proud to join with the outstanding leadership of this Committee in executing upon the policies that will allow the U.S. to *reclaim* its global leadership position in this great American born industry. Our use of the word "reclaim" is intentional. Because as of today, we have ceded global leadership to the nuclear industries in China, certainly, but also to Russia, South Korea and France. The U.S. designed the structures and protections inherent in international nuclear commerce in the 1950s, 1960s and 1970s. Those systems, while not perfect, have generally served the safety and security of the world well. But those systems will also evolve over time, and without a strong U.S. commercial nuclear industry leading and changing the world for the better, we will lose our ability to influence inclusion of the highest levels of safety and security. The U.S. must reclaim our global leadership role, for our own energy security, national security, and to ensure the highest standards for safety for our world.

We at X-energy stand ready to continue to work with this Committee and Congress in this grand endeavor.



Harlan Bowers, *President*

As president of X-energy, Harlan defines corporate strategy, implementation and oversees the development of a smaller, safer, next-generation nuclear reactor that expands reliable, zero-emission nuclear energy into entirely new markets. Harlan has over 32 years of experience managing very large, complex new business initiatives and highly technical engineering development programs. Much of his background has involved aerospace systems projects with NASA and commercial customers, as well as engineering services contracts up to $750M in value. Harlan has managed 50+ large proposal efforts for contracts with the Department of Energy, Department of Defense, Federal Aviation Administration, United States Geological Survey, and the Internal Revenue Service. His most recent responsibilities were with Stinger Ghaffarian Technologies (SGT) where he was Senior Vice President, Business Development, achieving new contract bookings of $1.36B for 2014 and 2015. Prior to that, he was VP/Program Manager for a $130M/year NASA engineering services contract, delivering systems for Hubble Space Telescope servicing, satellite remote sensing, and International Space Station operations. Harlan received a B.S. in Aerospace and Ocean Engineering from Virginia Tech and an MBA from the University of Maryland, College Park.

Chairman WEBER. Thank you, Mr. Bowers.
Dr. Parsons, you're recognized for five minutes.

TESTIMONY OF DR. JOHN PARSONS, CO-CHAIR, MIT STUDY ON THE FUTURE OF NUCLEAR ENERGY IN A CARBON-CONSTRAINED WORLD

Dr. PARSONS. Thank you, Chairman Weber, Ranking Member Veasey, and Members of the Committee. Thanks for inviting me here to discuss the findings of MIT's two-year research effort conducted by a large team, including other institutions such as Idaho National Laboratory. I've submitted written testimony, and I'll use this time to summarize.

The nuclear industry is faced with a great opportunity in the coming decades. The world needs much more energy, but at the same time, the world has to dramatically reduce its carbon emissions. Nuclear power is a proven scalable source of low-carbon electricity, and the industry should be well-placed for growth. And yet the grim reality is that the outlook for the industry is dim, especially here in the United States.

Our team has sought to understand the reasons for this disparity between the opportunity and the current reality. We took a fresh look at the assumption that nuclear power is needed to decarbonize the electricity sector, we examined the factors behind the alarming rise in the cost of new nuclear power plants, and we explored technologies and design options that may radically reduce that cost and the value proposition for advanced nuclear technologies.

Our analysis demonstrates that nuclear power is indeed—does indeed have a vital role to play in decarbonizing the electricity sector. While a variety of low-carbon technologies are now available, nuclear power can make a distinct contribution to the portfolio because it is a dispatchable low-carbon technology. In most regions of the United States, according to our analysis, including nuclear as one element of the portfolio dramatically reduces the cost of reducing carbon emissions.

Nevertheless, the industry does face a fundamental problem. While other generating technologies have become cheaper in recent decades, new nuclear plants have only become costlier. Our analysis shows that the major source of cost are the large civil works surrounding the nuclear reactor in the power system. This includes the large concrete structures that are the foundation and the surrounding containment building, but also many other components of the plant. It is on these civil structures and their construction that attention must be focused. Important advances in an array of technologies that we highlight make it possible to reduce the cost of building these pieces while simultaneously improving safety.

Changes to industry and practices and regulatory procedures are necessary to bring these into use, and we discuss those. These technologies are essential to any type of reactor, including advanced concepts. Without them, no concept can rely on its inherent features alone to be cost-efficient.

Looking to advanced reactor designs, we highlight that these provide important inherent and passive safety features. reducing the likelihood of severe accidents while also mitigating the offsite consequences of any accident that might occur. Our assessment is that the U.S. regulatory system is flexible enough to accommodate licensing of advanced reactors, but further leadership is needed to realize this possibility. We recommend ways to accelerate licensing reviews while simultaneously making them more effective in safeguarding the public.

We also recommend that the United States establish sites where the government can assist and supervise companies as they explore new reactor concepts and demonstrate safe performance. In the United States, sites like the Department of Energy's Idaho National Laboratory and Savannah River National Laboratory have many valuable assets and capabilities. They could be useful in designing safety protocols, seeking environmental approvals, and providing initial fuel cycle services.

This committee has supported similar ideas in legislation, and we thank you for that. The United States should also further develop funding programs to support demonstration of these new designs, as we detail in our report.

Even where all of these recommendations followed, another important ingredient is still missing. Currently, U.S. electricity markets do not compensate nuclear power plants for one of the most valuable attributes: being carbon-free. Both existing plants and investments in innovation and new builds would benefit from a level competitive playing field that fully rewards contributions to decarbonizing the electricity sector. Policies that disadvantage nuclear energy vis-a-vis other clean energy sources discourage that essential investment, raising the cost of decarbonization and slowing progress toward climate change mitigation goals.

Many more findings emerge in the course of that research, and I'd be happy to discuss them with you. Thank you for your time.

[The prepared statement of Mr. Parsons follows:]

The Future of Nuclear Energy in a Carbon-Constrained World: an MIT Interdisciplinary Study

Dr. John E. Parsons
Massachusetts Institute of Technology

Testimony before the Subcommittee on Energy,
Committee on Science, Space and Technology,
United States House of Representatives,
in a Hearing on "Advancing Nuclear Energy: Powering the Future"
September 27, 2018

Chairman Weber, Ranking Member Veasey, members of the committee,

My name is John E. Parsons. I am a Senior Lecturer in the Finance Group at the MIT Sloan School of Management and a Co-Director of the recently released MIT study on the Future of Nuclear Power in a Carbon-Constrained World.

Thank you for inviting me to discuss the findings of our report, which is the culmination of two years of research by a team from MIT and other institutions (among them, INL). Our team confronted a stark disparity that has developed in recent years between the opportunities for growth of the nuclear industry—opportunities created by the global growth in demand for electricity and the urgent need to reduce global carbon emissions—and the dim reality of stagnation for the industry worldwide, but especially here in the U.S.. We sought to understand the reasons for the disparity. In particular, we took a fresh look at the assumption that nuclear power is needed to decarbonize the electricity sector. We also examined the factors behind the alarming rise in the cost of new nuclear power plants, and we explored technologies and design options that may radically reduce the cost. In particular, we examined the value proposition for advanced nuclear technologies. Finally, we explored the appropriate role that governments could play in the development and demonstration of new nuclear technologies.

The analysis in our study demonstrates that nuclear power has a vital role to play in achieving decarbonization of the electricity sector. In most regions of the U.S., as well as many other countries, serving projected load in 2050 while simultaneously reducing emissions will require a mix of electrical generation assets that is different from the current system. While a variety of low- or zero-carbon technologies can be employed in various combinations, our analysis shows that nuclear's role as a dispatchable low-carbon technology makes a distinct contribution to the portfolio. Without that contribution, the cost of achieving deep decarbonization targets increases significantly. Lowering the cost of nuclear has a significant impact on reducing the cost of decarbonization.

Nevertheless, the prospects for the expansion of nuclear energy remain decidedly dim in the U.S. and many other parts of the world. The fundamental problem is cost. Other generation technologies have become cheaper in recent decades, while new nuclear plants have only become costlier. Another problem is the failure to remunerate nuclear plants for the value of the low carbon electricity they provide.

We examined what is needed to arrest and reverse that trend. To address cost concerns, we recommend:

(1) An increased focus on using proven project and construction management practices to increase the probability of success in the execution and delivery of new nuclear power plants.

The recent experience of nuclear construction projects in the United States and Europe has demonstrated repeated failures of construction management practices in terms of their ability to deliver products on time and within budget. We detail the corrective actions that are urgently needed.

(2) A shift away from primarily field construction of cumbersome, highly site-dependent plants to more serial manufacturing of standardized plants.

Opportunities exist to significantly reduce the capital cost and shorten the construction schedule for new nuclear power plants. First, the deployment of multiple, standardized units, especially at a single site, affords considerable learning from the construction of each unit. In the United States and Europe, where productivity at construction sites has been low relative to manufacturing, we also recommend expanded substitution of factory production for on-site construction. The use of an array of cross-cutting technologies, including modular construction in factories and shipyards, advanced concrete solutions (e.g., steel-plate composites, high-strength reinforcement steel, ultra-high performance concrete), seismic isolation technology, and advanced plant layouts (e.g., embedment, offshore siting), could have positive impacts on the cost and schedule of new nuclear power plant construction.

It is important to emphasize the broad applicability of these recommendations across all reactor concepts and designs. Cost-cutting opportunities are pertinent to evolutionary Generation-III LWRs, small modular reactors (SMRs), and Generation-IV reactors. Without design standardization and innovations in construction approaches, we do not believe the inherent technological features of any of the advanced reactors will produce the level of cost reductions needed to make nuclear electricity competitive with other generation options.

In addition to its high cost, the growth of nuclear energy has been hindered by public concerns about the consequences of severe accidents in traditional Generation-II nuclear power plant designs. These concerns have led some countries to renounce nuclear power entirely. To address safety concerns, we recommend:

(3) A shift toward reactor designs that incorporate inherent and passive safety features.

Core materials that have high chemical and physical stability, high heat capacity, negative reactivity feedbacks, and high retention of fission products, together with engineered safety systems that require limited or no emergency AC power and minimal external intervention, will likely make operations simpler and more tolerable to human errors. Such design evolution has already occurred in some Generation-III LWRs and is exhibited in new plants built in China, Russia, and the United States. Passive safety designs can reduce the probability that a severe accident occurs, while also mitigating the offsite consequences in the event an accident does occur. Such designs can also ease the licensing of new plants and accelerate their deployment in developed and developing countries. We judge that advanced reactors like LWR-based SMRs (e.g., NuScale) and mature Generation-IV reactor concepts (e.g., high-temperature gas reactors and sodium-cooled fast reactors) also possess such features and are now ready for commercial deployment. Further, our assessment of the U.S. and international regulatory environments suggests that the current regulatory system is flexible enough to accommodate licensing of these advanced reactor designs. Certain modifications to the current regulatory framework could improve the efficiency and efficacy of licensing reviews.

Lastly, key actions by policy makers are also needed to capture the benefits of nuclear energy:

(4) Decarbonization policies should create a level playing field that allows all low-carbon generation technologies to compete on their merits.

The fact that nuclear power plants produce no carbon emissions is one of their most valuable attributes. Unfortunately, in many U.S. electricity markets these plants earn no return on that attribute whatsoever. In the few that provide some recognition of this value, the level is minimal. Investors in nuclear innovation must see the possibility of earning a profit based on selling their products at full value, which should include factors such as the value of reducing CO2 emissions. Policies that foreclose a role for nuclear energy discourage investment in nuclear technology, raising the cost of decarbonization and slow progress toward climate change mitigation goals. Incorporating CO2 emissions costs into the price of electricity can more equitably recognize the value to all climate-friendly energy technologies. Nuclear generators, both existing plants and the new builds, would be among the beneficiaries of a level, competitive playing field that fully rewards the contribution to decarbonizing the electricity sector.

(5) Governments should establish reactor sites where companies can deploy prototype reactors for testing and operation oriented to regulatory licensing.

Such sites should be open to diverse reactor concepts chosen by the companies that are interested in testing prototypes. The government should provide appropriate supervision and support—including safety protocols, infrastructure, environmental approvals, and fuel-cycle services—and should also be directly involved with all testing.

(6) Governments should establish funding programs around prototype testing and commercial deployment of advanced reactor designs using four levers: (a) funding to share regulatory licensing costs, (b) funding to share research and development costs, (c) funding for the achievement of specific technical milestones, and (d) funding for production credits to reward successful demonstration of new designs.

Many more findings emerged in the course of the research undertaken for this study. A copy of the full study is available at this link:

http://energy.mit.edu/research/future-nuclear-energy-carbon-constrained-world

JOHN E. PARSONS

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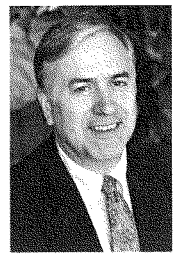

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BIOGRAPHY

Dr. Parsons is a financial economist specializing in risk management, corporate finance and valuation. His research focuses on the problems of risk in energy and environment markets, the role of trading operations in energy companies, and the valuation and financing of investments in energy markets. He is the Head of the MBA Finance Track, co-Director of MIT's CANES Low Carbon Energy Center, and an Affiliate of the MIT Center for Energy and Environmental Policy Research.

He holds a BA in Economics from Princeton University and a PhD in Economics from Northwestern University. He has taught on the finance faculty at MIT's Sloan School of Management, the Zicklin School of Business at the City University of New York's Baruch College and the Columbia Business School.

For ten years Dr. Parsons worked in the Finance Practice at the economics consulting firm CRA International, where he was a Vice-President and Principal. He worked with major international oil companies, mining companies and commodity processors, electric utilities and international pharmaceutical companies, among others on a wide variety of risk management and valuation matters.

Chairman WEBER. Thank you, Dr. Parsons.

Dr. Wagner, you're now recognized for five minutes.

**TESTIMONY OF DR. JOHN WAGNER,
ASSOCIATE LABORATORY DIRECTOR,
NUCLEAR SCIENCE & TECHNOLOGY,
IDAHO NATIONAL LABORATORY**

Dr. WAGNER. Chairman Smith, Subcommittee Chairman Weber, Ranking Member Veasey, Members of the Subcommittee, it's a pleasure and honor to be——

Chairman WEBER. Dr. Wagner, would you move—there you go. Thank you.

Dr. WAGNER. Is that better?

Chairman WEBER. Yes, sir.

Dr. WAGNER. Sorry about that. It's a pleasure and honor to be here with you today. I'm grateful for the opportunity to testify on implementation of S. 97, the Nuclear Energy Innovation Capabilities Act. I want to thank this Committee and your colleagues in the Senate for the vision, hard work, and persistence it took to get this important legislation to where it is today.

The NEICA bill takes significant steps to reestablish U.S. leadership in nuclear energy and support private-sector development and deployment of advanced reactors. My testimony will touch on how the Idaho National Laboratory, or INL, and other national labs will use these expanded authorities to support the private-sector effort to deploy advanced reactors.

First, the Versatile Reactor-based Fast Neutron Source or what we refer to as a virtual test reactor, or VTR for short, a fast neutron test reactor is needed to support testing of advanced fuels, materials, instrumentation, and sensors. Importantly, this is a capability the United States does not currently possess. Development and construction of this test reactor will eliminate reliance on Russia for these irradiation tests and reposition the United States at the forefront of developing and improving new nuclear energy systems.

The need for this capability has been well-documented, and as the NEICA bill moved through Congress, a multidisciplinary team of national labs, private companies, and universities have been assembled to develop the preconceptual design. The current schedule calls for the VTR to be operational by 2026.

Next, I'd like to discuss the establishment of a National Reactor Innovation Center, as called for in S. 97. In many ways, this approach harkens back to the decision in 1949 to establish the National Reactor Testing Station at what is now the Idaho National Laboratory. On this 890-square-mile site in the Idaho desert, the U.S. Government, including the Nuclear Navy and the private sector, built, tested, and demonstrated first-of-a-kind reactors that were later deployed around the world. As Subcommittee Chairman Weber mentioned earlier, 52 different reactors were demonstrated on that site.

The efforts in those days established U.S. nuclear technology leadership around the world for decades, and we're still building on that leadership today. We see the Nuclear Reactor Innovation Center as a place where government and private companies can come together to test and demonstrate new reactor designs, as well as materials, fuels, and other nuclear energy technologies.

As was done in the past for light-water reactors, such testing will enable advanced reactor deployment by demonstrating nuclear system operating performance and providing data and experience for licensing and data and experience for benchmarking of new computer modeling and simulation tools.

Finally, NEICA calls for expanded high-performance computing modeling and simulation capabilities to develop new reactor technologies. The current DOE modeling and simulation programs have made outstanding progress over the past decade for both current operating reactors and future advanced designs. In order to achieve the vision outlined in NEICA, experts in modeling and simulation of the national laboratories, along with the federal staff at the DOE Office of Nuclear Energy, are formulating an ambitious plan for the future of nuclear energy modeling and simulation as a single program to start in 2020, a program I'm calling ModSim2020. The vision for ModSim2020 is transformation through advanced modeling and simulation of the nuclear system design and regulatory paradigm from reliance primarily on empirical data to reliance on predictive simulations supported with limited experimental data.

NEICA truly arrived at just the right moment. I say that because NuScale and the Utah Associated Municipal Power Systems, or UAMPS, a consortium that serves more than 40 communities in seven Western States, are looking to deploy the first small modular nuclear reactors at INL by 2026. This project has been strongly and consistently supported by Congress.

Thank you.

DOE and INL are engaging with the Department of Defense, as recently encouraged by the National Defense Authorization Act, to develop microreactors and allow critical national security infrastructure such as military bases to be self-sufficient for their power needs. These microreactors could also be used for forward-deployed U.S. military bases and remote communities in places like Alaska. DOE and INL are working with NASA to look at advanced reactors that could support the power needs for manned space missions.

I appreciate the opportunity to summarize, both the private and public sectors have a great need for advanced reactor technologies. NEICA will help to meet those needs and ensure a future that is prosperous, clean, secure, and resilient. I appreciate the opportunity to testify, and I want to thank you again for your support and passage of the NEICA legislation. I look forward to any questions you may have.

[The prepared statement of Dr. Wagner follows:]

TESTIMONY OF

Dr. JOHN WAGNER, ASSOCIATE LABORATORY DIRECTOR, NUCLEAR SCIENCE AND TECHNOLOGY DIRECTORATE

IDAHO NATIONAL LABORATORY

BEFORE THE U.S. HOUSE OF REPRESENTITIVES COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY SUBCOMMITTEE ON ENERGY

"ADVANCING NUCLEAR ENERGY: POWERING THE FUTURE"

September 27, 2018

2318 Rayburn House Office Building

Washington, D.C.

Chairman Weber, Ranking Member Veasey and members of the subcommittee, it is a pleasure to be with you today. I'm grateful for the opportunity to testify on implementation of S.97, the Nuclear Energy Innovation Capabilities Act (NEICA). I want to thank this subcommittee, and your colleagues in the Senate, for the vision, hard work and persistence it took to get this important legislation signed into law.

The NEICA bill takes significant steps to reestablish U.S. leadership in nuclear energy and support private sector development and deployment of advanced reactors.

NEICA makes the unique capabilities of the Department of Energy's national laboratories available to the private sector and academia to accelerate innovation for advanced reactor development and deployment.

This far-reaching legislation:

- directs DOE to construct a Versatile Reactor-Based Fast Neutron Source;
- directs DOE to establish a National Reactor Innovation Center (NRIC);
- authorizes enhanced modelling and simulation capabilities to support advanced reactor development;
- and authorizes a cost-share grant program that will cover Nuclear Regulatory Commission fees to speed bringing advanced reactors to market.

My testimony will touch on how INL and other national labs will use these expanded authorities to support the private sector effort to deploy advanced reactors.

Let's talk about the Versatile Reactor-Based Fast Neutron Source, or what we refer to as the Versatile Test Reactor (VTR):

A fast neutron test reactor is needed to support testing of advanced fuels, materials, instrumentation and sensors. Importantly, this is a capability the U.S. does not possess.

Development and construction of this test reactor will eliminate reliance on Russia for these irradiation tests and reposition the U.S. at the forefront of developing and improving new nuclear energy systems.

In a parallel track with the NEICA bill, the need for this capability was recognized in February 2017 when a DOE Nuclear Energy Advisory Committee (NEAC) report recommended that the Office of Nuclear Energy "proceed immediately with pre-conceptual planning activities to support a new test reactor."

Since publication of this report, and as the NEICA bill moved through Congress, a multi-disciplinary team of national labs, private companies and universities have been assembled to develop the pre-conceptual design.

Following extensive engagement with relevant stakeholders, we have developed the functional requirements for the VTR. The mission need document, "Critical Decision (CD)-0 in DOE Order 413," is being prepared by DOE for submittal in January 2019.

Last week, $3.5 million in university awards were announced, to address various technical aspects related to the VTR.

Earlier this month, we selected several initial university proposals to participate in the VTR progam, with an emphasis on experimental designs, and we are negotiating the terms of the contracts.

In the near future, INL will award a contract to an industry partner to complete the conceptual design and cost estimate for the VTR. The current schedule calls for a completed conceptual design and cost and schedule estimate, as input to CD-1 in DOE Order 413, to be completed in 2021.

At that time, assuming approval of the CD-1 package, DOE can proceed with a procurement to hire an engineering and design company to complete the final design and construction of the VTR.

Throughout this process, under the direction of the Office of Nuclear Energy, the national laboratory, industry and university team is defining the long-term experimental program to meet U.S. industry and government needs.

The current schedule calls for the VTR to be operational by October 2026.

Next, I'd like to discuss establishment of a National Reactor Innovation Center (NRIC) to support advanced reactor development and demonstration.

In many ways, this approach harkens back to the decision in 1949 to establish the National Reactor Testing Station at what is now Idaho National Laboratory.

On this 890 square-mile site in the Idaho desert, the U.S. government - including the nuclear Navy - and the private sector built, tested and demonstrated first-of-a-kind reactors that were later deployed around the world. The efforts in those days established U.S. nuclear technology leadership around the world for decades.

We see the NRIC as a place where government and private companies can come to INL to test and demonstrate new reactor designs, as well as materials, fuels and other nuclear energy technologies. The NRIC at INL includes:

- Sites for testing and demonstration of new and novel reactors;
- Facilities that support research and development of advanced materials and fuels through unique R&D facilities for fuel fabrication, irradiation, and characterization;

- Integration of high-performance computing capabilities with experimental capabilities to create a new digital engineering approach to nuclear reactor development; and
- Laboratory, industry, and university partnerships to support the future workforce through training and education.

As was done in the past for light water reactors, such testing will enable advanced reactor deployment by demonstrating nuclear system operating performance, safety security and resilience, and providing data and experience for licensing and benchmarking of new computer modeling and simulation tools. It will improve safety performance, operating codes and security resilience of fuels and reactors.

In a manner that continues our leadership role for the DOE Gateway for Accelerated Innovation in Nuclear (GAIN) initiative, INL will serve as the interface to bring all of the national lab and university capabilities together to address the challenges brought to us by the private sector.

Finally, NEICA calls for expanded high performance computing (HPC) modelling and simulation capabilities to develop new reactor technologies.

DOE currently has two programs - the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program and the Consortium for the Advanced Simulation (CASL) Energy Innovation Hub - that are focused on bringing advancements in HPC to nuclear energy.

These programs have made outstanding progress over the past decade for both current operating reactors and future advanced designs. In order to achieve the vision outlined in NEICA, experts in modeling and simulation at the national laboratories, along with federal staff in the DOE Office of Nuclear Energy, are formulating an ambitious plan for the future of nuclear energy modeling and simulation as a single program to start in 2020 that I'm calling "ModSim2020."

The vision for ModSim2020 is transformation, through advanced modeling and simulation, of the nuclear system design and regulation paradigm from reliance primarily on empirical data to reliance on predictive simulations supported with limited experimental data. This program will focus on accelerating the development and deployment of advanced nuclear technologies through integration of modeling and simulation with experimental capabilities and programs.

ModSim2020 will take advantage of developments in the Office of Science Advanced Scientific Computing Research (ASCR) program through leadership computing facilities, the exascale program and related software development.

INL also is developing engineering-scale computing resources, through a new Collaborative Computing Center (C3), that will bring expertise and computing resources to support national laboratory, university and industry research, development and education.

NEICA truly arrived at just the right moment:

I say that because NuScale and the Utah Associated Municipal Power Systems (UAMPS), a consortium that serves more than 40 communities in seven western states, are looking to deploy the first small modular nuclear reactors at INL by 2026.

This project has been strongly and consistently supported by Congress.

Through the Joint Use Modular Plant (JUMP) program, and a potential power purchase agreement, DOE and INL are partners in the effort to deploy small reactors and develop a potentially large export market for U.S. industry.

DOE and INL are engaging with the Department of Defense (DoD), as recently encouraged by the National Defense Authorization Act, to develop microreactors and allow critical national security infrastructure, such as military bases, to be self-sufficient for their power needs.

These microreactors could also be used by forward-deployed U.S. military forces and remote communities in places like Alaska.

DOE and INL are working with NASA to look at advanced reactors that could support the power needs for manned space missions.

To summarize, both the private and public sectors have a great need for advanced reactor technologies. NEICA will help us meet those needs and ensure a future that is prosperous, clean, secure and resilient.

I also was asked to address issues where legislative direction and support could help us speed the deployment of advanced reactor technologies.

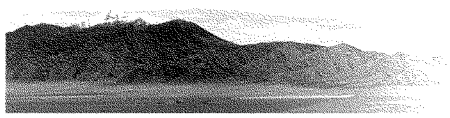
I'd like to highlight one of the most important areas where additional support is needed: helping DOE make high-assay, low-enriched uranium (HALEU) fuel available for advanced reactor companies – fuel with uranium-235 enrichment greater than the 5 percent enrichment commercially available today and less than the 20 percent-enrichment safeguards limit.

The U.S. does not have commercial capability to produce this fuel, and DOE is embarking on a couple paths to respond to this need.

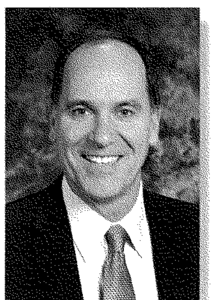
At INL, we have identified two potential sources of HALEU that DOE might be able to make available, but funding will be needed to prepare the material for subsequent fuel fabrication.

I'll conclude by saying that implementing the NEICA vision – and establishing a National Reactor Innovation Center - will challenge the DOE to develop new agreements and contracting mechanisms that enable more effective private-public partnerships, in which DOE assets and laboratory personnel are contracted to support private demonstration efforts.

I appreciate the opportunity to testify and I want to thank you again for your support and passage of the NEICA legislation. I look forward to your questions.



Idaho National Laboratory INL



John C. Wagner, Ph.D.
Associate Laboratory Director
Nuclear Science and Technology Directorate

Dr. John C. Wagner is the associate laboratory director of INL's Nuclear Science & Technology (NS&T) directorate. His previous roles included director of Domestic Programs in NS&T as well as director of the Technical Integration Office for the DOE-NE Light Water Reactor Sustainability Program at INL. Wagner initially joined INL as the chief scientist at the Materials and Fuels Complex in 2016. He has more than 20 years of experience performing research, and managing and leading research and development projects, programs and organizations.

Wagner received a B.S. in nuclear engineering from the Missouri University of Science and Technology in 1992, and M.S. and Ph.D. degrees from the Pennsylvania State University in 1994 and 1997, respectively. Following graduate school, Wagner joined Holtec International as a principal engineer, performing criticality safety analyses and licensing activities for spent fuel storage pools and storage and transportation casks. Wagner joined the Oak Ridge National Laboratory (ORNL) as an R&D staff member in 1999, performing research in the areas of hybrid (Monte Carlo/deterministic) radiation transport methods, burnup credit criticality safety, and spent nuclear fuel characterization and safety.

While at ORNL, Wagner held various technical leadership positions, including technical lead for postclosure criticality in support of DOE OCRWM's Lead Laboratory for Repository Systems, Radiation Transport Methods Deputy Focus Area lead for the Consortium for Advanced Simulation of Light Water Reactors (CASL), and national technical director of the DOE Office of Nuclear Energy's Nuclear Fuels Storage and Transportation Planning Project. Wagner also held various management positions, including group leader for the Criticality and Shielding Methods and Applications, Radiation Transport, and Used Fuel Systems groups.

In 2014, Wagner became director of the Reactor and Nuclear Systems Division (RNSD), with responsibility for management direction and leadership to focus and integrate the seven RNSD R&D groups (Advanced Reactor Systems and Safety, Nuclear Data and Criticality Safety, Nuclear Security Modeling, Radiation Transport, Reactor Physics, Thermal Hydraulics and Irradiation Engineering, and Used Fuel Systems) and the Radiation Safety Information Computational Center. Wagner is a Fellow of the American Nuclear Society and recipient of the 2013 E.O. Lawrence Award. He has authored or co-authored more than 170 refereed journal and conference articles, technical reports, and conference summaries. He was the original developer of the A3MCNP and ADVANTG codes and led the development of the CADIS and Forward-Weighted CADIS hybrid transport methods.

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16-GA50024_R1

Chairman WEBER. Thank you, Dr. Wagner.

I'll now recognize myself for questions for five minutes.

This is for Dr. Wagner and Mr. McGinnis. And we'll start with you, Mr. McGinnis. We'll give Dr. Wagner a chance to wet his whistle. What is your specific role and planned approach to implementing my bill S. 97, the Nuclear Energy Innovation Capabilities Act?

Mr. MCGINNIS. Thank you very much. First, let me say obviously we stand ready to fully implement the law once it is—and at the point at which time the President signs it, but I can tell you that many of the activities that we are doing at the Department of Energy is certainly very much in line with the provisions. We greatly appreciate the leadership and support, the acknowledgment of the importance of fast spectrum test reactor, of which we do not have in this country, and just a couple have them around the world. And it is a great disadvantage for us, and it will absolutely inhibit us from being able to support this new bow wave of highly innovative nuclear reactor designs coming into the pipeline in the United States.

Certainly, also Idaho National Lab and the other national labs that we leverage effectively to support nuclear energy in the mission, they are well-positioned to support the approach for a national test center for reactors and also to work even closer with the Nuclear Regulatory Commission and the other key provisions.

Chairman WEBER. Yes, thank you for that.

And, Dr. Wagner, I want to come back to you. You actually said a couple things in your remarks that kind of addressed this. You said we want to continue to maintain leadership, and of course this will be a critical area to maintain leadership around the world. And I have to compliment—you said you're calling it ModSim2020, which to coin—it's kind of to reverse-engineer phrase. Instead of hindsight being 20/20, this is going to be foresight is 20/20.

Dr. WAGNER. I like that.

Chairman WEBER. So I appreciate that. So what is going to be your specific role in implementing this bill?

Dr. WAGNER. So we have significant roles in implementing this bill, along with the federal staff in the Department of Energy Office of Nuclear Energy. Actually, we've made tremendous progress already relative to the versatile test reactor. Let me kind of make some comments on that if time permits.

As I mentioned, the need for the versatile test reactor has been well-defined. There's several different reports and industry statements about the need, so we've been moving forward even in parallel with this legislation.

So with the relevant stakeholders, we developed the functional requirements for the VTR, the mission need document. What we refer to in DOE 413 language as Critical Decision 0 is being prepared now and will be submitted in January of 2019.

Last week, $3.5 million in university awards were announced to address the various technical aspects of the VTR. Earlier this month, we selected several initial university proposals to participate in the VTR program with an emphasis on experimental designs, and we're negotiating the terms of those contracts now. In the near future, INL will award a contract to an industry partner to complete the conceptual design and cost estimate for the VTR. The current schedule calls for a completed conceptual design and cost schedule estimate as input to what they call Critical Decision 1, or CD–1, to be completed in 2021. As I mentioned, the plan is for the reactor to be operational in 2026.

I can go on further. We have plans for the Nuclear Reactor Innovation Center, as well as ModSim2020 if you'd like more details on those——

Chairman WEBER. Well, and I appreciate that. And certainly we will look to those going forward, but I'm about to run out of time. I want to get to Mr. Bowers real quick to see how your company—if you at all—do you think that the implementation of NEICA will affect X-energy and its partnership with DOE national labs? I wanted you to weigh in on that, please.

Mr. BOWERS. Partnership with national labs, the example that I had cited in regards to development of fuel, it's important to recognize that at least 15 years if not 20 years of research and development was performed at both Idaho National Lab and at Oak Ridge National Lab in regards to this particular fuel form. And this fuel form is referred to as TRISO—we talked about that before—and specifically uranium oxycarbide. It's not manufactured anywhere else in the world. It is unique to the United States, and it provides a capability within the fuel to generate more power than our competitors in China or from other countries could.

So branching off from that understanding, from that capability, taking what those Ph.D.'s at Oak Ridge National Lab have learned and be able to translate that into the marketplace is key. So our goal is, as we build our commercial fabrication facility—and at the moment we are looking at Oak Ridge, Tennessee, as the potential location for that facility. It's strategic to locate the fabrication facility there because we would have not instant but very easy access to those Ph.D.'s as we're developing our commercial processes. If we have problems, issues that arise, we need some additional research to be performed to be able to go right back into the labs and use that capability.

Chairman WEBER. So I'm a little bit over my time. So suffice it to say your company is well-positioned to make that transition?

Mr. BOWERS. We are poised and ready and funded by Department of Energy to make that happen.

Chairman WEBER. Well, that's good to hear.

Mr. McGinnis, I want to jump to you real quick with the Committee's indulgence. You cited challenging market conditions and the availability of innovative technology as reasons as to why the nuclear energy sector is currently undergoing a transformative period. With that in mind, does it make sense for DOE to continue to provide substantial financial backing to any nuclear project that isn't A, scalable; B, cost-effective; or C, flexible? Is that going to be a hard corner to turn? What do you think?

Mr. MCGINNIS. Thank you very much. That's a very important point. First of all, I do want to qualify that there continues to be a very important role for large-scale nuclear reactors. In fact, the United States Department of Energy thanks the Congressional leadership support. We have what is considered the most advanced commercially available large passably safe set of reactors available in the world, and that is with Westinghouse's AP1000 and the ESBWR. That was hard-fought, strong, technical partnership over the years with the United States. We're proud to have supported that. Those reactors remain available. Four have now just been completed in China, the AP1000—we're looking to the two in Vogtle to get done. Those provide 60 and 80 years——

Chairman WEBER. You and a whole lot of people.

Mr. MCGINNIS. Yes.

Chairman WEBER. Keep going.

Mr. MCGINNIS. Yes, sir. But the fact is they do play very important roles. However, as I indicated, I believe that there is a far greater percentage of market out there, customers that want nuclear clean baseload nuclear, but these products, large and large, are just too large. They need product choice. They need to be able to go in and not bet the farm with the company's balance sheet. And so that's why we think that this is going to open up an entirely new market and give customers finally the option to access nuclear without the choice of betting the farm and waiting five, ten years to see any revenue generation.

Chairman WEBER. Yes, well, thank you for that. That was our hope. Thank you. And I apologize to the Committee for being over time.

Mr. Tonko, you are recognized for five minutes.

Mr. TONKO. Thank you, Mr. Chair, and thank you to all of our witnesses for joining us on what is a very important discussion.

Dr. Parsons, thank you for sharing some details of MIT's "Future of Nuclear Power" study. There are many members that want to see us make significant reductions in carbon pollution, and it behooves us to better understand the role that preserving existing nuclear capacity and developing new advanced nuclear resources might play in achieving that ultimate goal of deep decarbonization.

From the modeling done in your study, what did you find in terms of reaching that 90 to 100 percent greenhouse gas reduction?

Dr. PARSONS. Thank you. First of all, the existing nuclear reactors are absolutely essential for reaching even a modest reduction. They provide the lion's share right now of low-carbon electricity, and the cost of providing that is the cheapest of the ways to provide low-carbon electricity. So it's very concerning that some of those plants have recently been closed and that a number of them are economically threatened. A commitment to decarbonization really will require a commitment to keeping those reactors operating.

Mr. TONKO. And if nuclear is not part of the generation mix at those levels, what is the impact on electricity affordability?

Dr. PARSONS. Well, the major advantage of putting nuclear into the mix is to keep the cost of decarbonization from escalating. Nuclear keeps the costs lower and makes electricity much more affordable and the decarbonization task much more affordable.

Mr. TONKO. And what do you attribute to these costs? Is it primarily from the current cost of energy storage?

Dr. PARSONS. Right. Well, some of the most valuable low-carbon electricity sources such as wind and solar are reliant on the resource of the wind or the sun, and they're only available in certain hours of the day and at variable amounts during seasons of the year. In order to provide carbon-free electricity at all hours of the year, you would need a buildout of that capacity that's at a very, very high scale. So an initial buildout provides you what you need, but in order to cover all of the hours, the buildout starts escalating and the costs start escalating.

Mr. TONKO. If we continue to invest in R&D dollars for energy innovation, including both advanced nuclear technologies and storage, can we expect to reduce those costs?

Dr. PARSONS. Yes, nobody knows what the future holds. Each of these different technologies may be able to provide a critical contribution in the future. Batteries can be terribly valuable. Advanced nuclear can be terribly valuable. And we need to have, so to speak, many shots on goal in order to keep the opportunities available to society.

Mr. TONKO. And while many consider nuclear to be important in the overall efforts for a decarbonized energy future, I think there is equal concern by the reported cost overruns at the Vogtle plant. Dr. Parsons, can you help us understand where these unexpected cost are coming from?

Dr. PARSONS. Yes, you're certainly right that those costs are very critical and need to be brought under control. We did a significant amount of research on this, and we identified that most of the large—lion's share of the cost and certainly of the cost overruns are in the construction of the civil structures surrounding the nuclear reactor in the power system, and so that construction process needs to be dramatically rationalized and new technologies need to be applied to reduce the cost of those structures.

Mr. TONKO. And what recommendations would you offer to make certain that advanced reactors might be able to be constructed without those same concerns for cost overruns with the civil infrastructure?

Dr. PARSONS. Well, it's important to realize that these kinds of civil structures are essential to any kind of nuclear reactor, so whatever design one's developing, we need to make an investment in the construction technologies that will make all designs affordable. The kinds of research-and-development funding that this committee has supported that DOE has done in the past have created opportunities which we could utilize now to reduce those costs.

Mr. TONKO. And we don't always connect the dots between some of these breakthroughs in the foundation construction and the industries that might benefit from them, but it highlights the importance, I believe, of crosscutting research. Are there concerns that cuts in federal research may limit the potential of nuclear energy to reduce costs and improve safety?

Dr. PARSONS. Right. To meet the future, we need future technologies, and so the research-and-development funds that have been granted in the past have given us opportunities, but we're going to need many more to meet this challenge.

Mr. TONKO. Well, I appreciate your testimony and the role that nuclear can play in a decarbonization agenda. And thank you for the thoughtfulness behind the study.

Mr. TONKO. And with that, Mr. Chair, I yield back.

Chairman WEBER. Thank you, Mr. Tonko.

The Chair now recognizes Mr. Brooks of Alabama.

Mr. BROOKS. Thank you, Mr. Chairman.

Deputy Secretary McGinnis, I don't know if you're in a position where you can spread the word within the Department of Energy, but we need some help. In the Tennessee Valley there is a nuclear power plant called Bellefonte. TVA has spent over $6 billion on this facility. They recently sold it at public auction for $111 million, which may very well make it the biggest boondoggle in the history of the Federal Government, particularly with respect to non-defense. Perhaps there are some defense things that are competitive. And for that $6-plus billion spent, we've had this much electricity generated, zero.

There is an effort now to get that facility completed by the private sector. There are things that have to be done through the Department of Energy. If there's anything you can do sending the message back, I know that the people of Jackson County, Alabama, would very much appreciate it because the University of Alabama has projected that this facility, if completed, would generate over 1,000 jobs with an average salary of $136,000 per job. That's pretty doggone good in the State of Alabama.

So with that as a backdrop, let me talk a little bit more to the point of this hearing today. In 2017 there were 99 nuclear power plants in 30 States in the United States' operating fleet, which generated approximately 805 billion kilowatt hours of energy. This is equivalent to 20 percent of total United States electrical output and 60 percent of its emissions-free electricity. There's been some comment to that already. I want to reemphasize it.

One fingertip-sized uranium fuel pellet about this big can generate as much energy as 17,000 cubic feet of natural gas or 149 gallons of oil or 1 ton of carbon to kind of put it into perspective. We've got some political interest groups that would just assume that we not have any nuclear energy in the United States or on planet Earth for that matter. Very quickly, can you describe what the impact on America would be if we were to suddenly decide that we are no longer going to have nuclear energy? Over the next year or two what would be the impact on the power grid and the ability of America to continue to function as we are today?

Mr. MCGINNIS. The impact would be incredibly negative, substantive, and long-term not only from a resiliency perspective, needing to have 24/7, 365-days-a-year nuclear or electricity available, not just when the sun is shining and when the wind is blowing. I would submit that nuclear energy has an absolute necessary role in an all-of-the-above. And don't get me wrong; we need all of the above, but nuclear energy still remains utterly unique. As you indicated, sir, density of power. There is no other power source that provides the density of power.

There's another interesting fact. We have about 7,700 of all shapes and sizes electricity-generating plants around the country, wind, solar, natural gas, coal, you name it, 7,700. Now, it's 59 of those sites is nuclear, so less than one percent of all the generating plants in this country is generating 60 percent of our clean, 20 percent of our electricity. The density of power is unmatched, and the longevity, there is no other source that can go all out full power 24/7 for 18 to 24 months, so——

Mr. BROOKS. Let me try to interject for just a moment since I only got about a minute left and focus on things that I think the general public can better understand. What would be the impact on brownouts, blackouts where you have no electricity, or electricity rates if we were to eliminate the nuclear power production over the next year or two like a lot of these political activists over on the left want to do?

Mr. MCGINNIS. I can tell you that's exactly what we're looking at the Department of Energy, especially with the grid modernization initiative. We are very concerned if we were to exit nuclear. The impacts to the stability of the grid, the availability. Like Secretary Perry said, whether it's in the wintertime or in the summer, we want our family to be able to know that that power is available. And it's not just from natural-made, manmade threats, we have an evolving grid that is increasingly reliant on intermittent that's driven by when the sun is out and when the wind is blowing, and that is going to truly challenge our ability to deal with not when everything's going well but when things go wrong, and there will be times, whether it's manmade or natural, and we need to make sure our grid is resilient, and nuclear is an absolute fundamental element of that.

Mr. BROOKS. Thank you, Mr. McGinnis.

Mr. Chairman, I yield back.

Chairman WEBER. All right. Thank you, sir.

And, Mr. Veasey, you are now recognized for five minutes.

Mr. VEASEY. Thank you, Mr. Chair.

I understand that MIT published its first report on the future of nuclear power back in 2003, and I wanted to ask, Dr. Parsons, what are the most significant differences about the future of nuclear energy between the publication of that first report 15 years ago and now?

Dr. PARSONS. Yes, well, the situation has dramatically changed. On the one hand, we have some cheaper competing sources of energy, so America's cheap natural gas provides a cheap source of energy, unfortunately with carbon, but nevertheless beneficial for customers. And then renewables have become much cheaper, providing another great option for reducing carbon emissions and providing low-cost power.

Of course, the Fukushima nuclear disaster happened in between, and that has obviously raised public concerns, and that's a major important thing that needs to be addressed by the industry. And, dramatically, nuclear has not achieved the lower-cost targets that were advertised at the time and people hoped would be achieved. So nuclear faces significant challenges to be an important player in achieving our goals going forward, and that's why we did the study, to address those challenges.

Mr. VEASEY. How would you compare the merits of a technology-neutral price on carbon emissions to the merits of recent proposals by the Administration to subsidize nuclear and coal plants? As you know, that was a very controversial proposal that came out. And largely based on the arguments of their contribution to the reliability and resilience of our electric grid.

Dr. PARSONS. Well, the cases vary one by one, and the situations vary in different regions, but we investigated this problem and, as

I've indicated, if we let these nuclear power plants retire, that's going to lose one of our lowest-cost sources of low-carbon electricity. The value of these nuclear power plants is in the low-carbon characteristics. We haven't been able to find any unique or substantive other values above and beyond that that would provide an economic rationale for keeping most of these reactors open. But the value of the low-carbon electricity is more than enough to make these units competitive.

Mr. VEASEY. In your testimony you note that the growth of nuclear industry has been hindered by public concerns about the consequences of severe accidents in traditional gen-2 nuclear power plant designs. Can you talk about some of the advancements made by gen-4 reactors that you think would maybe help quell some of the concerns that the public has?

Dr. PARSONS. Sure. Well, first of all, I think by and large we believe that nuclear power is generally a safe form of producing energy, and the problems that we really face are with some of the emissions from other forms of energy that nuclear doesn't provide. But obviously, catastrophic accidents sear the mind of anybody who sees them. I personally remember waking up early in the morning in 2011, March 2011, and seeing the tsunamis in live action in Japan, and it was just very impressive and then in the days after watching the news in live action, seeing some of the explosions happen at that nuclear reactor. So I'm personally very clear on how that can impact you and make you appreciate the dangers facing things.

Many of these new reactor designs have a characteristic that not only do events like that happen less often but they control the operation of the plant in the event of an accident so that you don't have any likelihood of major explosions or disruptions of that sort. And if you went to such an event, they contain the dangers within the plant boundary, and so that's the hope of developing these reactor designs, that they would make it for the public something that would be perhaps more of a normal industrial accident, tragic whenever it happens but something more comprehensible and less difficult to understand.

Mr. VEASEY. Thank you. Mr. Chairman, I yield back.

Chairman WEBER. Thank you, sir. Mr. Hultgren, you're recognized for five minutes.

Mr. HULTGREN. Thank you, Chairman Weber. Thank you, each one of you. I appreciate your work, appreciate your time being here today. I'm going to address my first couple questions to Mr. McGinnis if I might.

What's the mission of DOE's Gateway for Accelerated Innovation in Nuclear, or GAIN, program? And I wonder if you could share some examples of industry partners licensing and commercialization processors were accelerated by this program?

Mr. MCGINNIS. Thank you very much. The purpose of GAIN is to essentially support a very streamlined, efficient access to our nation's, the Department of Energy's world-class nuclear-related facilities, whether it's Idaho National Lab or among the other 17 total labs in the complex. And as we've listened as carefully as possible from industry with feedback, and one thing we've heard was they need unfettered, efficient access to these facilities to be able to prove out, test out their innovative concepts. And many of these capabilities we have great investments from the taxpayer, and they are world-class. So it is very important to do that.

We have a multitude of companies that we provide support through GAIN, and so we're very proud of that, literally in the dozens, leading vendors, utilities, technology developers, fuel developers. It's a very successful program, and we look forward to continuing to support that program.

Mr. HULTGREN. That's great, thanks.

Also, Mr. McGinnis, we understand that there are some delays in DOE's site permitting process for privately funded reactors. What's the status of DOE's site use permit process for privately funded reactors, and what are some of the reasons for the delays?

Mr. MCGINNIS. I'm not sure of the specific references you're making, but I can say from the Idaho National Lab for which my office is responsible for stewardship-wise, we are very proud that Idaho has served essentially for, you know, the venue for 52 different first-of-a-kind reactors built in its history, and we have at least three agreements, site-use agreements right now with United States and other innovators. One is a microreactor, one is NuScale, which I think is really in the forefront in its position to potentially be our nation's first advanced small modular reactor.

We are working as hard as possible to make sure that these agreements are being let out in an efficient way. From a nuclear energy perspective, it's my understanding—and I've been watching them very closely—they are proceeding. We have those in place now. When we get applications through our Idaho operations office, we prioritize that. We get it. We are in an extremely challenging time, and time is not our friend. So we are going to continue to get the feedback to make it as efficient as possible and improve that process to make it as user-friendly as possible.

Mr. HULTGREN. Great. Thank you.

Mr. Bowers, X-energy's partnership with the Department of Energy, national laboratories, how is the intellectual property associated with your nuclear designs and concepts managed? And is there anything about this process that you believe could be improved?

Mr. BOWERS. Intellectual property is truly, as you have identified, a key aspect of what we're trying to accomplish. I can also take that from the perspective of we want to ensure that it remains a U.S. capability and protect that from an IT security perspective. The work that we are performing at Oak Ridge National Lab today, as I alluded to earlier, it really enables us to take our reactor and make it a thoroughbred in comparison to some of our competitors internationally. So it is very important for us to retain that and protect that.

As a small business, the DOE does allow us to apply for a patent waiver, and so we are able to claim patents associated with the work that we are performing both at the national labs and under contract with the DOE, and therefore, we have, you know, ownership of that and can proceed forward with that. So I would say to date the partnership has been good, and we continue to find new, innovative, and novel things that will make our designs better, and we have been able to retain the ownership of that knowledge as we move forward.

Mr. HULTGREN. Great. Quickly, Dr. Wagner, just a quick question for you. What is INL doing to support the management and archiving of legacy reactor test data?

Dr. WAGNER. Actually, that's a great question because there is a great deal of that legacy data out there, and it's in high demand from the reactor developers currently. And so actually we have a number of programs with other laboratories, including Argonne National Laboratory, to basically assemble, process, and make data available from past reactor experiments like TREAT and LOFT and EBR–II. Honestly, we need to do more, but we are working on that.

Mr. HULTGREN. Good. Again, thank you all. Chairman, thank you for hosting this Committee, and I yield back.

Chairman WEBER. Thank you, sir.

The gentlelady from Nevada is recognized for five minutes.

Ms. ROSEN. Thank you, Mr. Chairman and our distinguished panel, for joining us here today.

As we discuss the future of nuclear energy and developing technologies, the one question I really think we have to answer is this: Where will we store or dispose of the waste? Now, I'm from Nevada. As my colleagues on this committee have heard me say before, I strongly oppose our country storing nuclear waste at Yucca Mountain for many reasons. The site continues to present serious safety and environmental concerns, which are detailed in hundreds of contentions filed by our state. These alone will take years to address, but even if the site was greenlighted, it would take up to 50 years to build the infrastructure in Nevada and across the country and allow the waste to be cooled and shipped by road and rail through heavily populated communities like all of us represent.

So I have a two-part question for anybody who would like to jump in first. So to what extent are researchers and industry proposing solutions to the nuclear waste, the long-term storage problem that may not involve Yucca Mountain, and then what technologies are on the horizon that you believe could significantly reduce or even eliminate the need for large-scale long-term geologic repository for nuclear waste, for example, reducing waste in place?

Mr. BOWERS. Thank you. I'd like to start by talking about fuel cycle in that regard. We are moving forward right now with uranium-based fuel. I mentioned uranium oxycarbide, which does have—you know, we do have spent fuel at the end of our reactor's 60-year life, and there is a storage requirement and there are certainly measured in thousands of years of radioactivity of that material.

The high-temperature gas-cooler reactor does offer the opportunity to do a different fuel cycle, which is thorium-based. There is more thorium in the Earth than there is uranium. The way that the fuel would perform within the reactor is absolutely identical to how it would be worked using the uranium approach, and the half-life is measured on the order of a couple hundred years. So while there still is a storage requirement, the concern of millennium-long storage—long-term storage facilities becomes mitigated as we move forward and we can advance the technology for thorium-based fuel. Thank you.

Ms. ROSEN. Anyone else want to comment? Thank you.

Dr. PARSONS. So, first of all, I think any of the reactor technologies that we'd be discussing will all require some sort of short-term storage in some sort of long-term repository of one sort or another. So that's an inescapable choice that we have to make.

Secondly, we did not provide any new results scientifically about waste in our report, but we did highlight that there have been several studies done. Previously, we had done a study back in 2011. There's been a Blue Ribbon Commission. There are others that have provided sensible solutions and options for the United States. In particular, we highlight that it's very important to get consensus and consensus-based siting precisely because we do need to move forward. And there has been the demonstration of successful consensus-based siting in both Finland and Sweden, and it could be a very valuable thing. Investors in new technologies are very concerned if a piece of the arrangement has not been settled, and so settling a piece of the arrangement would help facilitate investments.

Ms. ROSEN. You just answered my next question on consent-based siting, so I'm going to move onto another question. Something that we talk a lot about in this committee is early-stage research and late-stage research. It's used in a very cavalier fashion sometimes in this 2019 budget as a rationale to cut one program, maybe fund another. We haven't really defined those terms I don't think adequately.

So is it your belief—Mr. McGinnis, I'll ask you this—that policymakers can and should draw a bright red line between basic and applied research or between early-stage and late-stage research or should we be realistic and identify where the government can play that valuable role in de-risking technologies to partner with industry?

Mr. MCGINNIS. Thank you very much. Those are very important points. I'm in an office that is an applied energy office, and I have the great fortune to be working with innovative first-of-a-kind designers such as here today. And the first-of-a-kind designs I think are dramatically different from a known technology that's in the market.

With regards to early-stage R&D, therefore, I would say that the idea of where early-stage R&D starts and stops, it's much greater down the pathway of deployment of a first-of-a-kind technology because it is so intensively technically driven, modeling and simulation, the materials, going through the entire stage of the NRC process. For example, of a first-of-a-kind, one might find themselves having to go back to what is called TRL–2 or 3 issues where they have to go back to the basic science.

So you have a flow of early-stage in a broader breadth for first-of-a-kind if that makes sense, but it is a very important point. I would say ultimately the sweet spot for the Federal Government in partnering with companies is when they have very challenging technical issues that they have not been able to dispatch, and that we the Federal Government are uniquely in a position using our advanced test reactors, our other sites to bring them to bear. So that's where we are proud to do that, and in my view it is consistent with the early-stage R&D is the focus with what we're doing here today with our technical partners.

Ms. ROSEN. Thank you very much.

Mr. MCGINNIS. Thank you.

Chairman WEBER. Thank you, ma'am.

And now, the Chair recognizes one of the newer members, the gentleman from Texas. Is it Victoria?

Mr. CLOUD. Victoria.

Chairman WEBER. Victoria, you're recognized for five minutes, Mr. Cloud.

Mr. CLOUD. Thank you, Chairman.

Thank you for being here. Thank you for hosting this Committee on advancing nuclear technology.

This is an important topic for me because we have a nuclear plant in our district in Matagorda County, so it's important of course to the nation. But, Mr. McGinnis, you mentioned in your testimony that nuclear power plants serve as bedrocks to communities across the country, providing high-paid, skilled jobs to almost half a million Americans. Of course, this is true in Matagorda County and in our district.

What I hear from the folks at the nuclear power plant in our district is that regulatory oversight by the Nuclear Regulatory Commission is heavy with low-value inspections and regulations that do little for the safety of public but drive up the cost in an industry that's among the safest in the country. In 2016 the Nuclear Energy Institute testified that since 2011 the NRC has on average nearly doubled the time it takes to review license renewal and power uprate applications. A study by the American Action Forum discovered that the average nuclear power plant must comply with regulatory burden of at least $8.6 million annually, and regulatory costs imposed on nuclear power plants by the NRC since 2006 have totaled $440 million. So, Mr. McGinnis, could you share with the Committee the Administration's view on the current regulatory environment?

Mr. MCGINNIS. Thank you very much. And I do want to also give a huge shout out for Matagorda County with a south Texas nuclear power plant. It is just an absolute example of resilient power, having gone through extreme weather events and been there with some amazing stories of the commitment of the employees at that nuclear power plant and the leadership of the county. So I want to thank Matagorda County for the leadership for really the country. We appreciate that.

With regards to the regulatory environment, I think, first of all, first principles is I believe that one can have an absolute top, top level of safety while seeking maximum efficiency, cost-effectiveness, and speed. I believe it is possible to continue to realize greater efficiency in the regulatory process. I believe that the leadership that is now at the Nuclear Regulatory Commission understands that. We see a lot of examples of them working hard to be as efficient as possible because time is money for these companies, and it is incredibly challenging to get these technologies, especially new innovative technologies, through a regulatory environment. And we want to do everything we can to support and not discourage these great innovators to come in and change the future of our nuclear energy landscape.

A couple of examples, we're working with the Nuclear Regulatory Commission to bring to bear our modeling and simulation capabilities. We have now the fastest supercomputer in the world now, and that's Summit in Oak Ridge. We have tremendous capabilities. NRC uses our assets. We're proud that we developed a draft set of guidelines for advanced reactors, submitted them, and they were largely accepted. We continue to partner with them, but I think everybody would agree, they included, that we want to continue to try and reduce the time and cost for these applications.

Mr. CLOUD. Thank you. Would you say that the current regulatory environment then matches or what would be your opinion on the regulatory environment versus the successful track record of existing nuclear plants?

Mr. MCGINNIS. Well, I think that for many understandable reasons, the regulatory environment is set up for the current reactors, large light-water reactors. That's what we've had for decades and decades. So what we're attempting to do is support in any way we can, recognizing the important independence of the NRC, to be ready with the expertise and the regulatory processes for these new disruptive technologies, some of which have very different attributes, some mentioned here today, passive safe systems that are designed to literally shut down on their own without any human intervention, any electric-driven pumps or motors in the event of a loss of offsite power or coolant.

That is revolutionary. Not only is it huge for public confidence to be able to look a citizen in the eye and say the next generation—while the reactors are safe here today, the next ones are gamechangers. These are reactors that will shut down on their own, and then you have market opportunity and distributed opportunity.

We see the NRC. They just exempted the electric pumps and motor requirement for NuScale, the first reactor going through this process. And the second thing they're looking at now is whether now do you need a 10-mile emergency planning zone? And if you don't, we have a distributed opportunity with safety built in that we never had, market opportunity. So I think there is strong significant progress being made, but certainly, they are working hard at the NRC to get ready for an entirely new class of reactors. That's the challenge.

Mr. CLOUD. Thank you.

Chairman WEBER. You may not know, Mr. Cloud, but when I was a state rep, those were the days before I got demoted—I had STP in my district. I had Matagorda County. In 2010 we went through, my staff and I, and watched them change out their fuel rods. That was pretty cool. And by the way, they have a 7,000—if I remember right, 7,000-acre water pond, cooling water pond and got great alligator hunting. I'm just saying.

The gentleman from California is now recognized for five minutes.

Mr. MCNERNEY. Well, I thank Chairman Weber for your personal anecdotes there. They're always useful and interesting.

I thank the panel this morning for coming in to testify. Mr. McGinnis, I was going to ask the failsafe question because I've always been nervous after the Fukushima disaster, but it sounds like you're on that one. I mean, if it's failsafe and it fails badly, then something's wrong with the system. So you're giving us assurance that these new designs are real failsafe, that they're passive, that they can shut down without human intervention, and if there's a disaster like a flood, they still won't cause problems?

Mr. MCGINNIS. Thank you very much. And I think the best person to answer that is a person leading one of those designs here today.

Mr. BOWERS. I was really hoping you would hand that one off to me.

Mr. MCNERNEY. Okay.

Mr. BOWERS. If you'll allow me.

Mr. MCNERNEY. Yes.

Mr. BOWERS. So the pebble bed or just in general the high-temperature gas-cooled reactors do have this capability to self-moderate themselves, so as the temperature rises and gets, you know, quote unquote, too hot, the reactivity stops. And so then as reactivity slows down, the temperature drops again and then this cycle continues to take place over several hours to several days.

So then the question is really has this ever been demonstrated? So for high-temperature gas-cooled reactors there have been a half a dozen built around the world over the last 40 years, and there have been three tests that were performed, one in Germany, one in Japan, and one in China where the coolant, which was helium in those cases, was evacuated from the reactor and then they watched the temperatures and the reactivity within the reactor to see what happens.

And as predicted by the physicists, the temperatures rose and then self-moderation took over. The temperatures dropped back down again, and the reactivity subsided. So it has been test-demonstrated passive safety that there was no need for any active systems to ensure that the reactivity was maintained under control.

Mr. MCNERNEY. So now that you've brought up the physicists——

Mr. BOWERS. I'm an engineer——

Mr. MCNERNEY. Okay.

Mr. BOWERS. —by the way.

Mr. MCNERNEY. I'm a mathematician, so we both have a thing with physics. But how about using artificial intelligence in designing reactors like the small modular reactors? Are we going to be able to use big data and artificial intelligence to come up with really highly effective designs? Dr. Parsons, would that be your bailiwick? No?

Dr. PARSONS. I will venture out a little bit on that one and maybe hit it on the side, which is to note that for the previous decades we have various modeling and simulation codes that have been developed, and the question is always how do you ensure that your code is accurate, that the numbers that you get out of it are correct? And that's always been performed via test, so you would set up a large-scale test of some kind, run that test, get results, test results, measurements, temperatures, et cetera, and you would compare that to the results that you're getting from your software codes.

The capabilities of software, the capabilities of computing power such as the cluster that's available at Oak Ridge National Lab really offers us an opportunity to reduce the cost of development and use modeling and simulation almost exclusively rather than relying on these very large complex test systems for verification, so I think there's a lot of opportunity in advanced modeling and simulation going forward.

Mr. McNERNEY. Thank you. I'm sorry I came in late. I was going to ask Dr. Parsons about his MIT report and using nuclear power to balance renewable energy and the cost that renewable energy might have without nuclear power. Could you expand on that a little bit, Dr. Parsons?

Dr. PARSONS. Sure. Well, I'll just say quickly that it's great that we've seen enormous cost reductions in renewable energy, and they've provided us a great opportunity to make some good steps forward in reducing carbon emissions. The problem is that the farther and farther you go in making reductions in carbon emissions, you start needing eventually to multiply your investments in the renewables. So the cost isn't linear. It becomes nonlinear as you go to really deep carbon reductions. And that's the role that we point out nuclear can play to cap that escalation of costs at—by balancing—providing the balance of power when renewables have a modest amount of resource available. And keeping that cap on I think would be important for accomplishing our goals.

Mr. McNERNEY. Is nuclear technology ready for that?

Dr. PARSONS. Certainly, nuclear technology is ready for that, but we do need to make it—if we can make some of the cost reduction targets we describe, it makes a big impact on how low that cap can be.

Mr. McNERNEY. Thank you, Mr. Chairman. Are you going to do another round of questions or is this it?

Chairman WEBER. Well, do I get to do my anecdotes?

Mr. McNERNEY. Please don't.

Chairman WEBER. The gentleman's time has expired.

The Chair now recognizes the gentleman from California.

Mr. ROHRABACHER. All right, Mr. Chairman. Were those alligators, did they glow in the dark?

Chairman WEBER. I've not gotten close enough to find out.

Mr. ROHRABACHER. All right. Let me just say thank you. I'm sorry I was late. When you're here, you've got three or four different things to do, and I've really appreciated the testimony I've heard so far, and I will be reading your submitted testimony in the meantime.

Are any of you advocating building new light-water reactors? Okay.

Mr. McGINNIS. Absolutely.

Mr. ROHRABACHER. Okay. We have a light-water reactor in my area, San Onofre, and they are now storing the rods that are left over, this nuclear waste, at a cost of $70 million a year, and no electricity is being produced for hundreds of years. Are you sure that it's worthwhile building light-water reactors?

Mr. McGINNIS. Thank you very much. First, I want to say that the new class of advanced reactors coming down the pike include both light-water and non-light-water. These designs in non-light-water are frankly I think in my view very exciting. They include these passive safe—some would call walkaway safe designs——

Mr. ROHRABACHER. Right.

Mr. McGINNIS. And certainly ultimately beyond that the class of reactors non-light-water, they're in a position to consume and reduce the amount of waste ultimately. But we certainly support also the full life of these reactors. I just got back from Pennsylvania at the State House where they have three reactors in Pennsylvania that are slated to shut down early. If they shut down early, they would wipe out all of the wind and solar contribution in the PJM market in all 13 states where PJM is in one fell swoop because you will lose that much emissions-free generation.

Mr. ROHRABACHER. Right. And how much of a danger do you think would be put upon the people of the area if they had a Fukushima-type incident because I imagine the Fukushima alternative was sold to the Japanese that nothing can ever go wrong. And then we end up with a catastrophe in Japan. And again, we've sold them on the light-water reactor.

Mr. McGINNIS. I have great faith in the NRC. We realized a lot of lessons learned from Fukushima and put them into the light-water reactor plans that are being operated today, but ultimately, I also believe it is absolutely necessary. We need to find a pathway to take the spent fuel that is on these sites and put them in a disposal in a repository and stop kicking the can.

Mr. ROHRABACHER. Yes, is it possible that the leftover waste—it's already been mentioned by Dr. Bowers—that some of that waste actually can be used as fuel for the next generation of nuclear power that would not be light water?

Mr. BOWERS. I will comment that there are advanced reactor concepts and designs that have been put forward that do take reprocessed fuel or spent fuel and can use that as fuel for their reactors. I will comment that that is not the design that we are moving forward with, but I know that Ed is very familiar with——

Mr. ROHRABACHER. I think that we should——

Mr. BOWERS. —some of those processes.

Mr. ROHRABACHER. When you consider we're saying that in my area in the middle of a residential area that we are going to be storing nuclear power rods for 1,000 years is unacceptable to anybody. And who knows what type of dangers will come up? Who knows if we'll have a California earthquake that then we're putting hundreds of thousands of people's—maybe millions of people's lives at stake with that type of reasoning. And I would hope that we would proceed, you know, and say light-water reactors had their day. What can we do now to improve nuclear energy and its ability to provide for the needs of the people of the country?

And, Mr. Bowers, you're mentioned on the high-temperature gas-cooled reactors. I think that there are a number of those alternatives that seem to make more sense that you're going to have far less waste and waste that perhaps can be used—we can use up the waste from the reactors before. Let me ask you this. Is any of this based on fusion energy? No? Okay. Well, how much money are we spending on fusion energy? We've spent billions of dollars developing fusion energy. Again, I believe that's a total waste. And the fact is we should use that money that we're spending on developing fusion and let's spend it on some of the ideas that you have for the next generation of fission that we know that we are capable of achieving. They say fusion energy is the fuel of the future, and it always will be. Well, the fact is we need something that we're going to invest in that actually is foreseeable that we are going to be able to achieve and not a dream.

And so, number one, I will read your report. I'm anxious. I think nuclear energy has a vital role to play. We are going to eventually run out—humankind will run out of fossil fuel eventually. It may not make sense right now, but even the things we're talking about are 10 to 20 years down the road, and if we're doing that, what's the price of gas and oil going to be like then? Well, I think it will be—it will totally justify the expenditure of developing a new generation of nuclear power. We need a new generation. We need to deal with the waste from the last generation.

And we should not—again, Mr. Chairman, one of the things I'm really worried about is that we do have profitmaking as part of the equation as to what direction we go. But the people that are thinking about profitmaking are not thinking at all about long-term effects on safety 100 years from now. They could care less about that. So it's up to our scientists, our engineers, and yes, elected representatives to take these things into consideration. We appreciate the guidance you've given us.

Chairman WEBER. Well, we've had a request for round two from my good friend from California, and since apparently I need to recompense with him over my comments, we're going to do that. And it helps me, too, Jerry. I've got some questions, too, so with your indulgence, this is for Dr. Wagner, Mr. Bowers, and Mr. McGinnis. In you all's prepared testimony, you all emphasized the need for DOE to support research that will make high-assay low-enriched uranium. Are you calling that HALEU? What are you——

Mr. MCGINNIS. HALEU or——

Chairman WEBER. HALEU? Okay.

Mr. MCGINNIS. High-assay LEU——

Chairman WEBER. Okay. Perfect.

Mr. MCGINNIS. —different terms of art.

Chairman WEBER. Fuel available for advanced reactor technologies. So what is HALEU fuel, and why is it needed to advance the next generation of reactor technologies? And, Mr. Bowers, we'll start with you.

Mr. BOWERS. Thank you very much. So we start with a definition, right? So all existing light-water reactors operate on fuel, enriched uranium that has enrichment of less than 5 percent, 4.8, 5.1, and down from there. The military needs for uranium start as well as some test reactors within the United States start at 20 percent and go up, so there is this no man's land, this range between 5 percent and 20 percent enrichment that's called high-assay low-enriched uranium. Several of the advanced reactors are looking to use high-assay LEU for their reactors that enables higher burnups, improved efficiencies, longer periods of time between outages, so there are a lot of benefits to using it.

Chairman WEBER. So why hasn't that been done heretofore?

Mr. BOWERS. Uranium demand for product has been driven by what the market currently requires, which is light-water reactors at five percent, so no one's going to build a factory to make something that makes eight percent if no one's going to buy it. And the needs for the test reactors is relatively small, and so that's been able to be supported by DOE, Y–12, and other sources within the United States. I'll stop there.

Chairman WEBER. Mr. McGinnis?

Mr. MCGINNIS. Well, I don't want to add more to his technically sound description, so let me just describe briefly the demand. There is no high-assay LEU commercially available on the planet right now. We—the majority of the new——

Chairman WEBER. Not even for testing?

Mr. MCGINNIS. There was——

Chairman WEBER. Oh, you're saying commercially available?

Mr. MCGINNIS. Commercially available.

Chairman WEBER. Okay.

Mr. MCGINNIS. So no U.S. company that is looking to bring in their reactor, right now, they have no high-assay LEU fuel. They have no fuel for their design. And that creates a great risk. The closer they get to trying to deploy, they can't sustain that risk not knowing there is none. That doesn't mean that enrichment facilities can't move forward when they see enough of a market, a custard demand, but we have a chicken and the egg here.

Chairman WEBER. Is that a short startup time?

Mr. MCGINNIS. Not that short. To be able to get this established with the high-assay LEU, you're talking a couple years at least, so it's not going to be immediate. However, that's where I think the Department of Energy is in a unique position to help spur and support at least the laboratory scale if not a little bit larger scale for the demonstration of high-assay LEU for these new reactors to provide the confidence. We have microreactors. Many people may not realize this. They may be coming in as early as 2021, 2022. These are reactors that will need high-assay LEU so——

Chairman WEBER. Are you calling SMRs microreactors?

Mr. MCGINNIS. Microreactors are smaller than SMRs, so microreactors, depending on the definition—in general it's 1 to 5 megawatts electric. Some define it up to 50 megawatt, but in truth, most of the microreactors are about 1 to 5 megawatt electric. But 1 megawatt electric, that supplies power to 1,000 homes, so it's not insignificant. So we have a very near-term need for the ability to provide confidence to these new innovators in markets that high-assay LEU will be available when needed.

Chairman WEBER. Okay. Thank you. Dr. Wagner?

Dr. WAGNER. I would just add that some of the accident-tolerant fuel concepts for the existing light-water reactor fleet are also looking at enrichment above 5 percent, more in the lower range, 5 to 8 percent, so some of those concepts also have a need here for this fuel as well, whereas the advanced reactors are primarily looking at right close to 28 percent. With the support from the Department, we are actually taking several steps, but we need to do more. Some of that is initially recovering high-enriched uranium from spent fuel such as our EBR–II fuel and——

Chairman WEBER. And that's what France does?

Dr. WAGNER. No, France reprocesses commercial light-water reactor fuel, so five weight percent and below. So what we're doing is we're recovering the uranium from our old EBR–II spent fuel and down-blending it to 20 percent, so there are some sources there for the very near term that might support one of the microreactors, for example, but we've got to get a longer supply out. There's other opportunities to increase that in terms of recovery from other spent fuel sources, but long-term, we'll need an enrichment capability in this range.

Chairman WEBER. Thank you. With your indulgence, Mr. McNerney, I'm going to ask Mr. Bowers one more technical question.

You talked about systems that can shut themselves down. You evacuate the helium, you remove off the coolant, and then you watch the system as it basically self-regulates. How in the world does it do that?

Mr. BOWERS. I did start out by saying I'm an engineer, not a physicist, but I can take a stab at it.

Chairman WEBER. Okay.

Mr. BOWERS. Which is that within the uranium there are what's called resonances, and in these resonances at certain temperatures, rather than emitting neutrons, the uranium absorbs the neutron. So when you get to a particular temperature, you've got neutrons being absorbed instead of being expended, and that's basically what fuels the reaction.

Chairman WEBER. So that's not an implosion on itself.

Mr. BOWERS. Yes.

Chairman WEBER. What happens when they absorb those neutrons?

Mr. BOWERS. It returns to a more stable state, and the temperature goes down within the——

Chairman WEBER. Do you have a temperature——

Mr. BOWERS. —core.

Chairman WEBER. —range for us? Do you know what that temperature range is?

Mr. BOWERS. Is between 1,000 and 1,100 degrees centigrade. Our reactor operates around 900 degrees C——

Chairman WEBER. Okay.

Mr. BOWERS. —and the outlet temperature on the helium is approximately 750 degrees C.

Chairman WEBER. And time frame, is that 15 minutes, 15 hours? What's the time frame?

Mr. BOWERS. You know, a cycle like that is predicted to be on the order of 25 to 35 hours, and so each day or two days you'd see it cycle up and cycle back down again, and it would continue in this kind of state for weeks if necessary until powers was returned and you could——

Chairman WEBER. So you restore it to arrest that cycle for lack of a better term or to restore it to its original——

Mr. BOWERS. To arrest the cycle, insert the control rods is the way that we would accomplish that——

Chairman WEBER. Okay.

Mr. BOWERS. —and we actually have in our particular design, two separate banks of control rods, one for operation and trimming performance and the other for shutdown.

Chairman WEBER. Well, I want to ask you why that is, but I won't, so the gentleman from California——

Mr. BOWERS. Defense in depth.

Chairman WEBER. The gentleman from California is recognized for his questions.

Mr. MCNERNEY. Well, I thank the Chairman. And the Chairman will be interested to learn perhaps that our colleague Mr. Flores and I introduced a bill called the Advanced High-Assay Low-Enriched Uranium Act, H.R. 6140, in the Energy and Commerce Committee, and it was passed out of committee to enhance the cycle of producing high——

Chairman WEBER. This session?

Mr. MCNERNEY. Yes, this session, so that's—it was going to be taken up on the Floor this week, but for some reason it was pulled. And so I want to talk a little bit more about that. Thank you for carrying the water on that for me.

Mr. Bowers, you said, in your testimony, that by 2023 we'd have to have fuel ready for these reactors. What role do you see the private industry can play in establishing this supply chain?

Mr. BOWERS. Supply chain of the high-assay LEU?

Mr. MCNERNEY. Yes, sir.

Mr. BOWERS. So to recognize that where X-energy intends to play is fuel fabrication, which means high-assay low-enriched uranium comes into our facility in the form of an oxide and then we use that to create kernels and particles, et cetera, that are then pressed into the form that we require. So it's like a raw material to us. And while—if we were—the people today that have the capability of generating low-enriched uranium is URENCO in New Mexico, and they are the only producer today or what's referred to as an enricher in the United States.

In terms of where else I could—if the question is where could I in terms of executing my business plan—get high-assay low-enriched uranium——

Mr. MCNERNEY. Well, the question really is what role do you think that private industry can play in establishing that supply chain?

Mr. BOWERS. So I'll say this. There are companies in the United States—Centrus Energy is one that once upon a time had significant enrichment capability. They still have the engineering and knowledge and understanding of what it takes to construct and operate an enrichment facility. And so private industry is prepared to do that. I think this again falls into that chicken-or-the-egg element, which is what is the demand for low-enriched uranium between 5 and 20 percent, and if that demand is evident and orders are ready to be placed, a company will step forward and make that investment. But somehow, we have to kickstart or jumpstart that industry.

Mr. MCNERNEY. And the Federal Government can be helpful in that?

Mr. BOWERS. Very helpful.

Mr. MCNERNEY. Thank you.

Mr. BOWERS. Thank you.

Mr. MCNERNEY. Mr. Bowers, I was going to read this question because it's a little complicated, but regarding Nuclear Regulatory Commission licensing, the Committee has repeatedly received testimony over the past several years that the current licensing framework is not suited to efficiently assess new generation of nuclear reactors. As you mentioned, the NRC and the DOE and the industry have taken some steps to modernize the licensing process and help alleviate some of the licensing cost. What specific regulatory changes would you like to see, and what steps can the NRC and other agencies make that would help this process become more efficient and quicker?

Mr. BOWERS. I think there's broad agreement on the changes that the NRC intends to put in place and recognition from industry of what those benefits would be. During my testimony, I mentioned the licensing modernization program, and the goal of that program is to establish a different way of looking at reactors and how we license them. I like to use the example of a volume control, and so there's a requirement of—I've got my car, right? I want to listen to the radio. I need a volume control, and so the requirement is I need to be able to control the volume. The way the NRC would look at that requirement is that it would say the knob needs to be 1 inch in diameter and needs to be painted black and it needs to have white numbering on it, so very prescriptive in terms of how the requirement is met. And that works when every reactor is based upon the same technology, i.e., light-water reactors.

As we move forward and we have different technologies, molten salt, high-temperature gas, fast reactors that the NRC will need to regulate, they have to come up with a different paradigm as to how they will ensure safety of those systems. And so moving to something called risk-informed performance-based assessment or analysis is the framework that they're looking to move to. And they're in the process of doing that.

We have just started our pre-application engagement with the NRC, and so it's a little early on in the process. We've had a couple meetings with them, very anxious to move forward, kick the tires with the NRC and help them understand our technology and help them with that new framework.

Mr. MCNERNEY. Thank you. Mr. Chairman, I'll yield back to you.

Chairman WEBER. Thank you, sir.

The gentleman from California is recognized for his questions.

Mr. ROHRABACHER. Thank you.

And, Dr. Parsons, in your prepared testimony you discussed creating a site where companies can deploy prototype reactors. And let me just note that we have—with your leadership—provided legislation, H.R. 431, which is Chairman Weber's bill, and that's about to be signed into law. And we appreciate your leadership, Mr. Chairman, and your guidance on this, so that—I think we've done—we've taken a step in the right direction. I would imagine that's part of your testimony today.

Dr. PARSONS. Indeed, we thank you for that.

Mr. ROHRABACHER. Okay. Let's look at this. Again, I don't want to dwell on the fact that nuclear energy I believe is inherently dangerous, but we have to do certain things that are dangerous in order to succeed in achieving certain goals for civilization. The Chairman was asking about how these things could be determined in case of an emergency, it would shut down that, and, Mr. Chairman, I think HAL will make all those decisions for us. You remember HAL?

Chairman WEBER. That was quite some odyssey, wasn't it?

Mr. ROHRABACHER. HAL in the Space Odyssey 2001 was the computer got out of control. And we have already had, some people suggest—Elon Musk for one of them—that if we go too far down the road of everything robotic and letting them make decisions, perhaps wrong decisions will be made that are beyond our comprehension today. So as we move down that direction, obviously whatever system we put in place will have to have a computer systems that will deal with the new challenges that are brought up.

Again, I would just suggest—and I don't have the engineering background, but from what I have heard today and from what I have gleaned from other hearings that we've had is that light-water reactors are inherently more dangerous than what we are capable of building in terms of the non-light-water reactors. Mr. Bowers, is that correct?

Mr. BOWERS. I would phrase it a different way, which is that the light-water reactors require active safety systems to maintain safety, and the advantage that the—and these are generation 2 and generation 3 reactors. The advantage that the generation 4 reactors bring is that rather than having active safety systems that require human intervention, you have passive safety systems that do not require a human to ensure safety of the system. And I'll let Mr. McGinnis——

Mr. ROHRABACHER. Well, inherently, do we not have more leftover waste from light-water reactors than we would from the high-temperature gas-cooled reactor, for example?

Mr. BOWERS. I'm going to say that no free lunch. You know, we create nuclear spent fuel the same way that a light-water reactor does. Ours is packaged a little different. Rather than it being in control rods, we're in pebbles.

Mr. ROHRABACHER. Well, the question isn't length of time. The question is amount of waste that we have to deal with. I am under the impression that light-water reactors will produce more nuclear waste stuff that we deal with as compared to high-temperature gas-cooled reactors, for example. Is that correct?

Mr. BOWERS. I'm going to pass on that if I may and get back to you with an answer. I'm not a spent-fuel expert, so forgive me.

Mr. ROHRABACHER. But go right ahead.

Mr. MCGINNIS. Thank you very much. I would just love to have had some of our great innovators in NuScale and Holtec and frankly some of the other companies here that are working on game-changing both non-light-water and light-water reactors. Literally the one that is progressing with partnership with Idaho National Lab, UAMPS, municipal utility in the Utah region with a number of States, this design is going through the NRC now. They're very conservative at the NRC, and it's a light-water design.

And so I would ask that if we could at least open the spectra a bit and give this design an opportunity to see whether NRC validates that this light-water small modular reactor design can safely shut down on its own. And they've already validated that.

Mr. ROHRABACHER. I'm more concerned about——

Mr. MCGINNIS. Yes.

Mr. ROHRABACHER. —also the amount of nuclear waste. We have a storage facility that's being put at San Onofre right in the middle of a huge residential—I'm talking about millions of people live around San Onofre, including my family I might add. And if there is a system that will produce less nuclear waste at the end of the process, we should go in that direction, and especially if we can build a system that eats some of the waste that's already been given to us and eats some of that as fuel. So I would hope that we go and get really serious in terms of not just planning how to produce electricity but how to deal with that waste as part of the equation.

Thank you very much, Mr. Chairman.

Chairman WEBER. Thank you, sir. I want to thank the witnesses for their valuable testimony and the Members for their questions. The record will remain open for two weeks for additional comments and written questions from the Members. The hearing is adjourned.

[Whereupon, at 12:01 p.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Edward McGinnis

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
SUBCOMMITTEE ON ENERGY
Questions for the Record Responses from Principal Deputy Assistant Secretary for Nuclear Energy Edward G. McGinnis
"Advancing Nuclear Energy: Powering the Future"

September 27, 2018

QUESTIONS FROM REPRESENTATIVE ROSEN

Q1. American ingenuity is clearly at work as so many advanced nuclear technology companies are seeking to perfect their technology and bring these next generation clean energy concepts to market. As you look around the world, how important is it that the United States remain the leader in commercial nuclear technology? Also, what countries pose the stiffest competition to ours and what is your office doing to help make sure American companies not only compete, but thrive, in the international market?

A1. It is critically important that the United States (U.S.) remains the leader in commercial nuclear technology. U.S. nuclear technology sets the highest global standards of safety and nonproliferation and our continued leadership in the commercial nuclear technology sector will only continue to ensure these high standards globally.

Nuclear energy is an essential element of the Nation's electricity sector, grid reliability, resiliency, and national security, including our international goals and objectives. State-owned enterprises from countries such as Russia and China pose the most significant threat and competition to U.S. nuclear technology venders. These state-owned enterprises make it difficult for U.S. nuclear technology companies to compete in the global commercial nuclear market place mainly through their use of aggressive financing, much of which does not follow Organization for Economic Co-operation and Development guidelines.

The Administration recognizes that the U.S. nuclear energy sector is under historic economic downward pressure as we have witnessed a number of nuclear plants prematurely retire from service and several more planning to retire in the near future. Along with these closures, there has been significant degradation in our manufacturing base as U.S. companies have lost a tremendous share in the dominant global market. As a result, the Department of Energy's (DOE) Office of Nuclear Energy (NE) is working to revive, revitalize and expand the Nation's nuclear energy enterprise by sustaining the long-term viability of the existing U.S. nuclear reactor fleet, establishing an advanced reactor pipeline of new technologies, establishing and maintaining key national strategic fuel cycle infrastructure, and rebuilding U.S. influence in the international commercial nuclear market place.

DOE leads the interagency effort called "Team USA" to coordinate an approach to support U.S. industry as it competes for international projects. This support includes policy development in the areas of nuclear commerce, export promotion, advocacy, financing, research & development and other nuclear-related infrastructure. The approach also includes diplomatic engagements to leverage the weight of the U.S. Government and help level the playing field for U.S. companies against state-owned companies in international markets.

Q2. Can you speak to the utility that advanced reactors could provide, particularly to national defense installations? Does the DOD provide the best opportunity to site a first of a kind reactor and demonstrate the capability to the commercial market?

A2. We believe that it would not be appropriate for DOE to speak for the Department of Defense (DOD) before DOD has a validated requirement.

Q3. DOE has already made significant expenditures to assist the development and commercialization of small modular reactors (SMRs) and advanced reactors. For Fiscal Year 2019, the Energy and Water Appropriations bill included an additional $100 million for SMR and advanced reactor development. As you know, appropriations for these programs are not limitless, and we must evaluate funding priorities every year. Can you please highlight what has been achieved with the funding Congress has already provided, and tell us what nuclear technologies and grant programs should be prioritized if Congressional appropriations were to become more restrained in the future?

A3. Over the previous decade, DOE has supported the development of a number of advanced nuclear reactor designs, with a focus on SMRs. Through the SMR Licensing Technical Support Program, DOE competitively awarded nearly $400 million to partner with multiple innovative domestic SMR vendors and utilities to develop these technologies

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and begin the process of licensing for operation at domestic sites. As a result of this Congressional funding, in January 2017, DOE's cost-share funding recipient, NuScale Power, became the first U.S. SMR vendor to submit an application for design certification to the Nuclear Regulatory Commission for staff review, which is expected to be completed in September 2020, with the final rule to be issued approximately one year later.

In fiscal year 2019, NE will continue to support SMR and other advanced reactor development projects through the previously mentioned U.S. Industry Funding Opportunity Announcements, which are providing cost-shared funding for the development of new concepts, capabilities, and technologies that will help to establish an advanced reactor inventory. DOE's future funding priorities will be established through the Budget process.

Q4. DOE's future funding priorities will be established through the Budget process. The MIT report points out that small modular reactors present an opportunity to shift away from the primary field construction approach currently used to construct large nuclear reactors, to centralized manufacturing or factory fabrication of reactor modules that are deployed in the field. Can you explain how this approach could reduce capital costs and construction schedule/timelines to complete SMR plants?

A4. The field construction or stick built approach to nuclear reactor plant projects involves performing all construction activities on-site, such as setting reinforcement bar, pouring concrete, joining metal large components, and making precise alignments in the field. In doing this, construction crews encounter adverse impacts such as wind, precipitation, temperature fluctuations, and other conditions that make such activities more challenging. Modular construction allows major parts and components to be fabricated and finished in climate-controlled environments and transported to the site for pre-aligned assembly. Modular plants will be designed for similarity in parts so there will be cost savings in mass production.

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While first-of-a-kind plants will likely not be less expensive than one-off, field construction plants due to start-up costs in the factory environment, (e.g., setting up tooling and fabrication processes), amortization of these costs over multiple units is expected to decrease overall costs. Additional savings should be achieved over time through manufacturing efficiencies and the ability to do controlled regulatory and quality inspections on limited part inventories in the factory environment, versus 100% field inspections. Once parts are fabricated and delivered, field construction schedules are also expected to decrease due to the ease of assembly of modular parts and components. Reduced construction schedules should have a significant positive cost impact.

Responses by Mr. Harlan Bowers

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"Advancing Nuclear Energy: Powering the Future"

Mr. Harlan Bowers, President, X-energy

Questions submitted by Rep. Neal Dunn, Member, Committee on Science, Space, and Technology

1. **Funding and actually siting a first of a kind reactor is challenging because the utilities and industrial customers will not commit to moving forward before another one is built first. This is a problem for U.S. nuclear technology both domestically and internationally. Mr. Bowers, can you shed some light on how companies like yours look to deal with this problem – and how we look to make it easier to turn a design into an actual operational reactor?**

At the root of your question is, generally, how do we move to commercialize new technologies, and get the First-of-a-Kind built with all the associated technical, costs and schedule risks. This is where the government can play a significant role – in mitigating the risks enough to begin to transition to private investment. An interesting analogy is the development of commercial space launch vehicles. A recent Inspector General report has stated that NASA has spent $17 billion, to commercialize cargo and crew launch vehicles between FY11 and FY17. While Elon Must got much publicity for launching a tesla on the first Falcon 9 launch, the fact of the matter is that this was not done for publicity, but because no paying customer would fly on the first-of-a-kind vehicle. This is not just the situation with Space X, but is true of the first launch of any new launch vehicle.

This is a similar situation with nuclear reactors. However, these risks are exacerbated with new nuclear reactors, as they go through a much more elaborate licensing process, with an agency, the NRC, that hasn't licensed a non-light water reactor in over 30 years. So the confidence in the cost and the schedule of getting through the licensing process as originally laid out, is not very high. Having the government as a funding and market creation partner in moving through this process, does give a significant signal to potential customers and investors that these technologies are a high priority for the US government, both for our own energy generation as well as competing internationally. Consequently, a public private partnership that focuses on getting the design work accomplished to the point of getting to and through an NRC license is generally the milestone that both customers and investors look at to gain enough confidence in a company to back its construction. However, depending on the technology and what has been demonstrated in the past, there is still a significant amount of risk associated with a new reactor through the completion of a First-of-a- Kind plant. It is really only at this point that all the commercial funding would be available.

X-energy has been in discussions with various utilities, as well as investment bankers to ascertain what it will take to both sign up a customer and get the financing to build the first plant. In fact, X-energy has formed a Customer Advisory Committee made up of representatives from Southern Company, Duke Energy, Exelon, and SCANA. From the "first customer" side, there are a couple of issues. One has to do with the timing of domestic utilities' needs for additional power versus the strategic advantage of having advance reactors compete internationally. For the most part, electricity demand in the US is flat, or even slightly down. Utilities do not see augmentation of their energy generation capacity until after 2030 at the earliest, with the biggest need closer to 2050. Therefore, there is no urgency, from the utility side to commit to advanced reactors now. They can wait until they see which companies and technologies make it through the licensing and finaincing stage and are available after the 2030 timeframe. Additionally, utilities are reluctant to sign up too early in the design process, until they understand the licensing process, isssues and schedule with a particular technology. However, internationally, there is significant growth in the electricity market. Since nuclear reactors typically last 60-80 years, if the US is going to compete internationally, we must act NOW, and be in on the first round of decisions. If we wait until the US electricity is ready to buy more capacity, we will be missing out on the second generation of nuclear reactors world-wide. This timing not only has export and industrial base consequences, but national strategic security issues as well.