# Testimony of Christina Back, Ph.D.
## V.P., Nuclear Technologies and Materials, General Atomics
## Before the U.S. Senate Appropriations Committee Subcommittee on Energy and Water
## January 16, 2019

Chairman Alexander and Senator Feinstein, thank you for inviting me to speak on advanced nuclear reactors.

America is losing one of its most important sources of clean electricity generation at the very time that diverse and reliable clean energy sources have become more important than ever.

The largest single source of carbon-free electricity generation – more than 50% in the U.S. – is nuclear energy. Yet, year by year, more nuclear plants are being shut down.

If we want to ensure that our electricity grid remains as clean, if not cleaner, than it is today, then we must make sure that we bring new nuclear power plants online. That means the U.S. must **reduce substantially the cost** of future nuclear reactor systems that can not only generate less waste, but even consume existing nuclear waste.

It also means that the U.S. now needs to make long-term investments to help develop the new technology. We cannot get where we need to go by using sixty-year-old water-cooled reactor technology. The U.S. should be in the forefront of exploiting the technological advances that have occurred since then.

A robust nuclear power industry is important for the national and energy security of our country. If the US is going to lead the world into a future of nuclear power, we must develop advanced reactors based on new technologies that meet all of the criteria you established in the FY 2014 Energy and Water Appropriations bill: namely, that they would "dramatically improve nuclear power performance including sustainability, economics, and safety and proliferation resistance."

General Atomics has an extraordinarily talented staff that has designed and developed reactors optimized for particular needs. We developed the TRIGA reactor for non-power applications such as neutron radiography and for training future generations of nuclear scientists and engineers. Sixty-six were sold throughout the world, and they are so safe that they are even sited at hospitals. We also demonstrated the first commercial high temperature gas-cooled reactor showing the advantages of helium gas instead of water as a coolant. More recently, we are designing an ultra-safe and transportable very small modular reactor (vSMR), or micro-reactor, that is suitable for DoD installations where electricity costs are very high, and energy security is of paramount importance.

By incorporating scientific advances of the last 60 years, GA's future nuclear reactor builds on our decades of experience with helium reactors. We call it the Energy Multiplier Module, $EM^2$, and it uses materials engineered for extreme conditions, and new technologies to efficiently convert heat to electricity. This reactor is designed to accomplish all of the Subcommittee's goals for advanced reactors.

Specifically, $EM^2$ at either its full scale of 265 MWe per reactor, or demonstration scale of 50 MWe would:

- Be even safer than existing LWRs, by further reducing the risk of Fukushima-like events
- Increase thermal efficiency by at least 60 percent over current and projected water-cooled reactors. We believe this increase in efficiency will be the driver in cutting nuclear electricity costs by nearly half, making them much more competitive with coal and natural gas

- Convert nuclear waste from a liability into an asset by using it as part of the fuel used by this new reactor. This capability can effectively eliminate the argument that nuclear waste represents an insoluble problem
- Decrease significantly the upfront capital required to build a reactor by making small modular reactors that could be manufactured in factories, transported to the site, and brought online within five years
- Significantly reduce the proliferation risks associated with nuclear power production, and
- Enormously increase the number of locations suitable for reactors by making it possible for them to be sited away from large bodies of water

If we are able to successfully demonstrate this reactor, we will truly revolutionize this industry!

The key to progress today is to make judicious investments to reduce the uncertainties of using new reactor materials and new technologies, thus enabling the U.S. to leapfrog to significantly higher power generating efficiencies. As an example, GA's engineered silicon carbide composite material, named SiGA™, is a ceramic fuel rod material that does not melt and qualitatively improves the resistance to intense high temperature and neutron radiation conditions. Another key technology meriting serious investment is new high uranium-density fuels to improve fuel efficiency. Capitalizing on new technologies will require development work and DOE can play a leading role in shepherding the next generation of nuclear reactors.

With all of these rapidly advancing technologies, the reactor for tomorrow is not the reactor of today. A sustained amount of funding is needed before we, or anyone else, could decide to build a pilot plant. Our reactor concept may not be the only one that aims to meet the Subcommittee's goals. Thus we recommend that you encourage the development of any reactor concept that can meet all of this Subcommittee's objectives.

However, we're up against a real challenge – there is enormous pressure to build a reactor as soon as possible, using only existing technologies. If we do not make the investments NOW in new materials and innovative technologies, we will be missing out. It's as if we decided to make small incremental changes to rotary phones instead of embracing advances in microelectronics that make possible today's smartphones, which all of us seem to have.

In our view, it would be of great help if the Subcommittee would consider funding a small number of **new technology** advanced reactor concepts, each in the range of $10-$30 million annually for 4-5 years. This level would allow further development of these concepts to determine whether they can fulfill their promise. Any recipients would have to pay their required cost share. Funding would continue, or terminate, depending on their progress.

Also, the traditional methodology of licensing which relies only on experimental data is outdated, and needlessly long and expensive. Today, with better understanding of the underlying science, and the speed of modern computing, normal and off-normal operations can be quickly simulated for many scenarios to assess and quantify risk. This has led to a budding effort named Accelerated Fuel Qualification (AFQ). AFQ is a methodology that brings together modeling and simulation, with targeted experiments, to assess the materials and their performance. I am convinced this integrated approach can modernize licensing to reduce time and cost, without sacrificing safety. This methodology is used in other disciplines and must be embraced.

To facilitate a timely deployment of new reactor materials and technologies, it would be important to fund the DOE and NRC to develop and implement this AFQ methodology. This support could start at about $15 million for the first two years, growing to about $50 million five years out. This effort would involve industry, academia, and the National Labs.

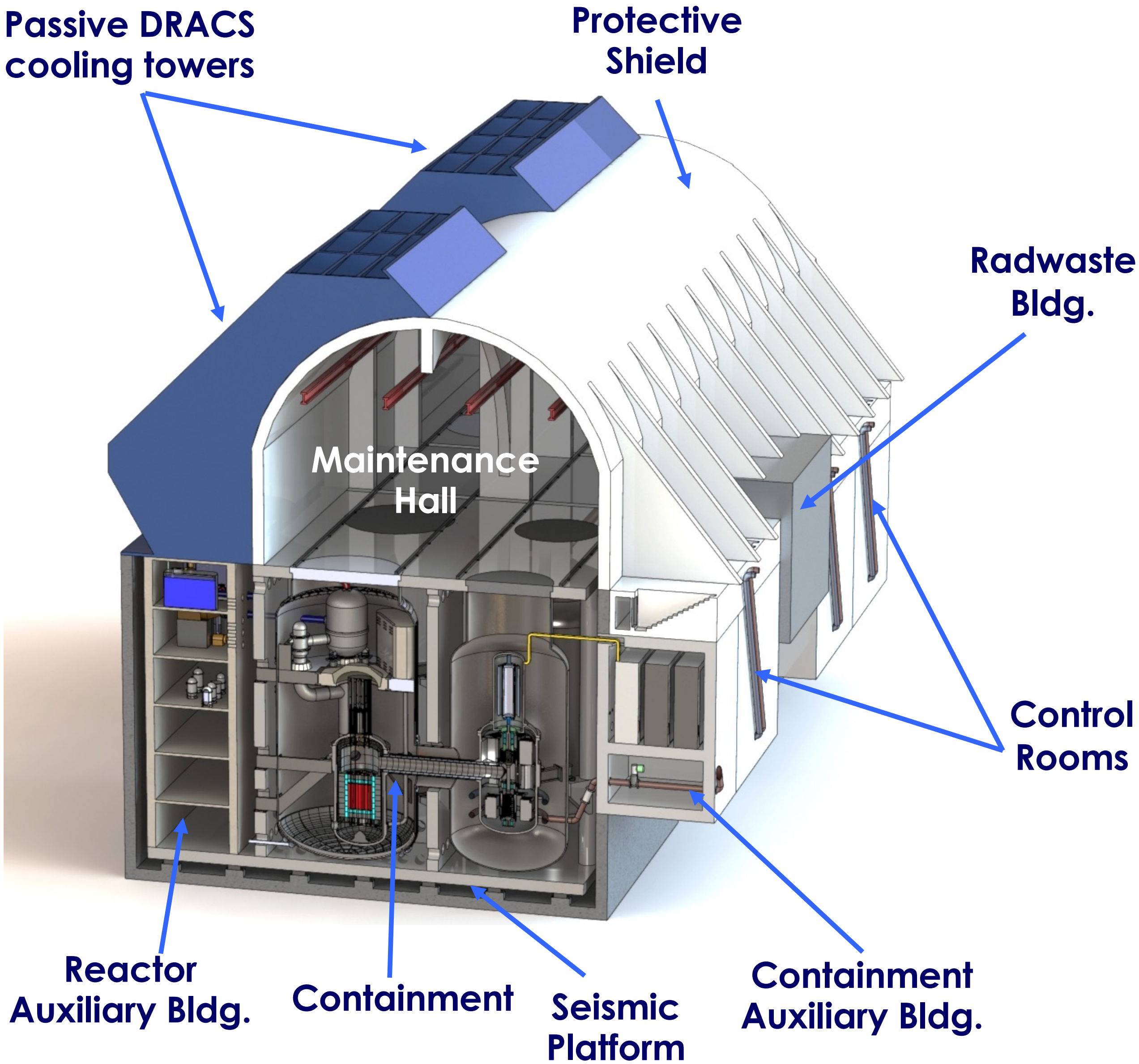
We have received small levels of assistance from DOE for which we are grateful. Now we need your support to ensure that these new, exciting longer-range, technologies are not left behind in the rush to build reactors whose performance may fall short of becoming game changers.

We thank you for the creation of, and continued support for, the Accident Tolerant Fuel Program. GA now is applying our $EM^2$ silicon carbide technologies to develop fuel rods for the current LWR fleet. These ATF SiGA rods facilitate LWR lifetime extensions and enhance their safety by making Fukushima-like events even more unlikely.

In closing, I believe we are on the threshold of developing and demonstrating advanced materials and technologies that can make nuclear energy attractive once again. Please come to San Diego and visit our laboratories to see how these materials can transform the nuclear industry.

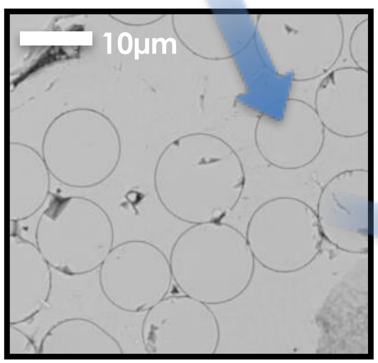
Again, thank you for inviting us today. I am happy to answer any of your questions.

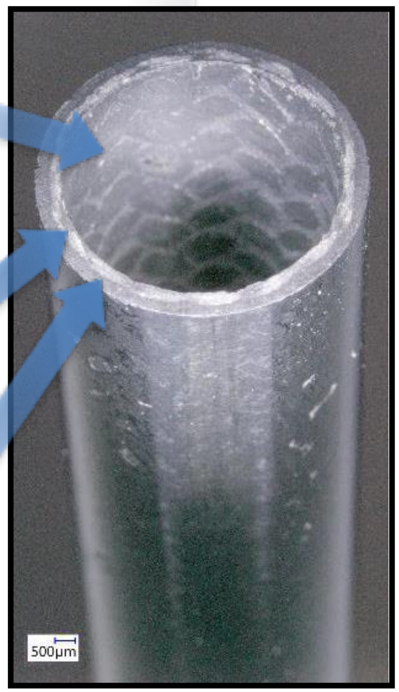
# The Energy Multiplier Module ($EM^2$) Is a Modular Nuclear Plant Optimized for the 21st Century Grid




- No need for water cooling
- 80% less high-level waste than an LWR
- Passively safe
- Advanced physics core enables 30 year life
- Proliferation-resistant fuel recycle

# Accident Tolerant Fuel (ATF) Uses New Materials For Enhanced Safety and Fuel Cycle Efficiency




Inner SiC-SiC

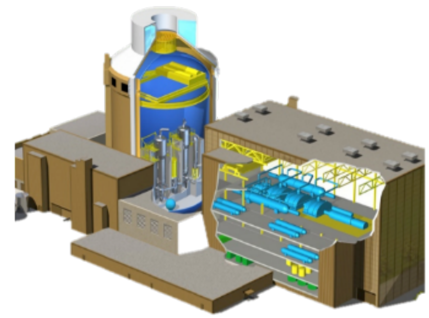
Outer Monolith

## SiGA™

**Silicon Carbide Technology developed by General Atomics**

**Ceramic does not melt**

**Light Water Reactor**



## SiGA for LWRs

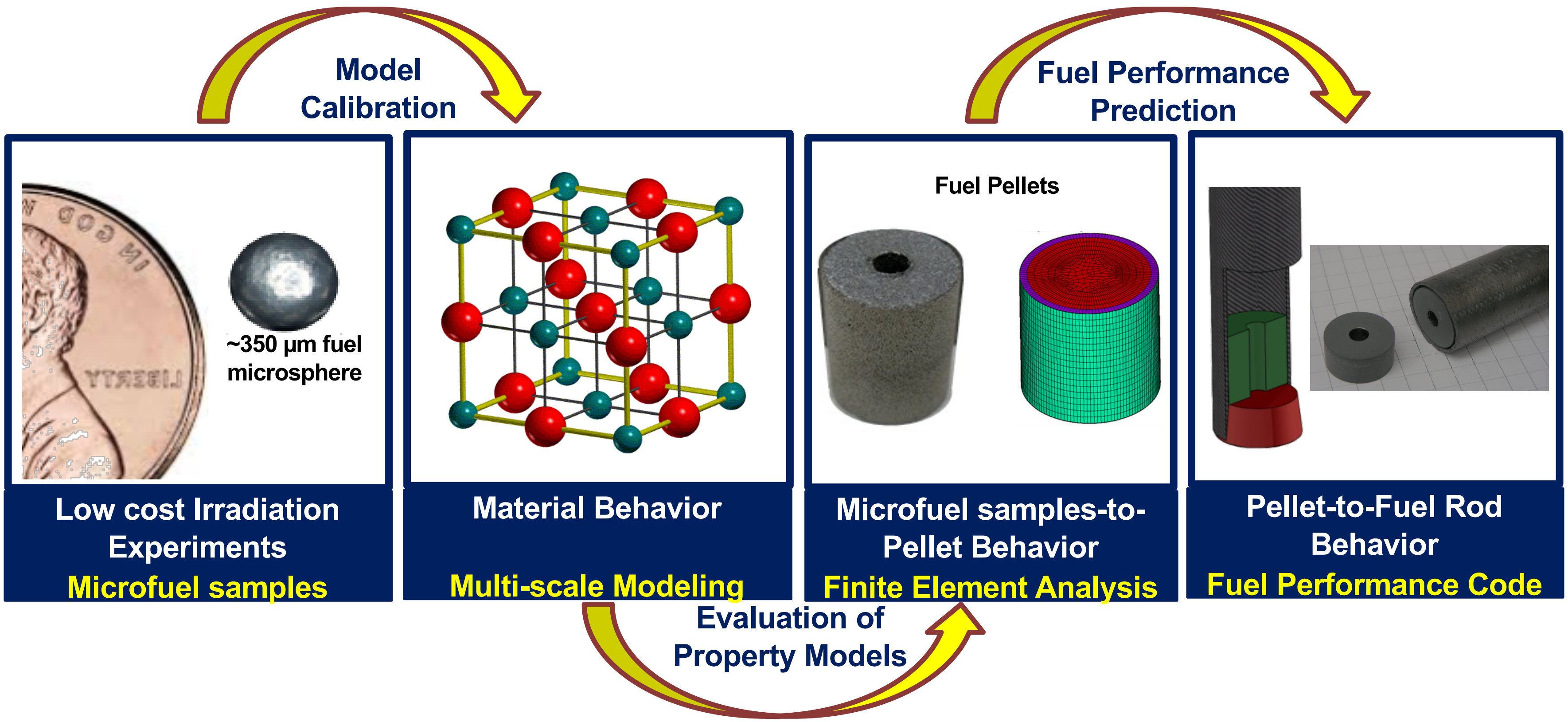
- Greatly enhances safety
- Improves economics



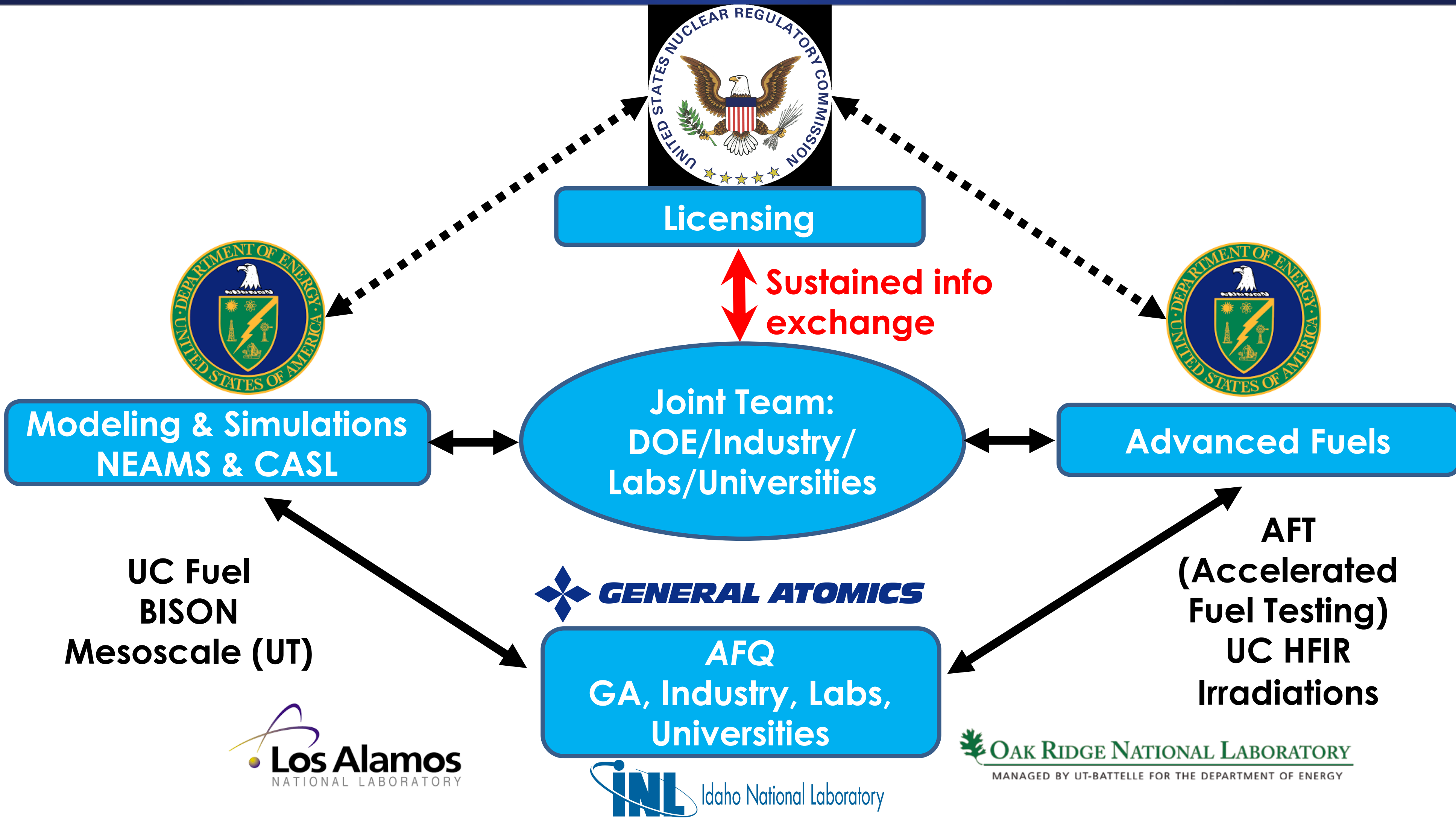
SiGA™ is a trademark of General Atomics

# GA Is Developing Accelerated Fuel Qualification Methods (AFQ)

- **Reduce the schedule and cost burden associated with qualifying new materials for nuclear reactors**
  - Use high-speed computing to supplement experiments
  - Efficiently benchmark computer simulations with data



# AFQ Framework and Key Stakeholders




**Building a coalition of partners with DOE's overall coordination**