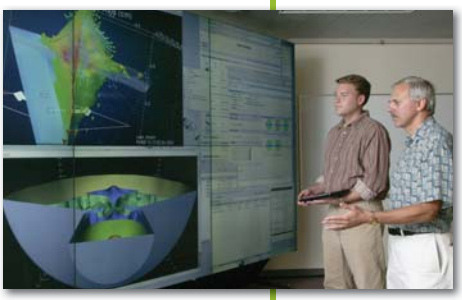
Energy Innovation Hub for Modeling and Simulation

The U.S. Department of Energy's Office of Nuclear Energy

The Energy Innovation Hub for Modeling and Simulation will provide new ways to address safety, waste management, and nonproliferation.

The Energy Innovation Hub for Modeling and Simulation will be modeled after highly successful endeavors such as Bell Labs and the Bioenergy Research Centers. It will utilize existing advanced modeling and simulation capabilities (*e.g.,* computational fluid dynamics) developed by the Department of Energy's (DOE) Office of Science, National Nuclear Security Administration (NNSA), and other DOE research and development programs to fundamentally change how the U.S. designs and manages its nuclear facilities. Over the past decade and a half, a new capability has been added to theory and experimentation to create and demonstrate scientific insight about complex physical systems. With the advent of very high-powered computing, advanced modeling and simulation can provide faster and more detailed insights into the operation of these complex physical systems. The goals are to find ways to improve waste management, reduce proliferation risk, and lower the cost of nuclear facilities.



NEW WAYS OF UNDERSTANDING

Using the world's most powerful computers, the modeling and simulation hub will provide new ways for scientists and engineers to advance nuclear energy technologies. This will provide a faster technology innovation cycle while reducing risk and cost. Today's immersive visualization technology will allow scientists and engineers to stand in the center of an operational "virtual" reactor, observing coolant flow, nuclear fuel performance, and even the reactor's response to changes in operating conditions, accident conditions, or design parameters. This approach will provide the critical research and development insight needed to develop nuclear power systems that are better understood, more readily licensed, and even safer to operate.

The design and licensing of current reactors was based on conventional engineering that relied on a series of incremental steps moving from prototypes to demonstrations to commercial power plants. Without significant experimentation, validation and verification, the engineering development processes had to ensure the designs were sufficiently conservative to cover a lack of precise models to simulate system behaviors under steady state, transient, and potential accident conditions. This process led to a technology development and licensing process that was long and expensive, and resulted in overly conservative designs. Modern, science-based, integrated modeling and simulation such as what the Hub will provide, will allow engineers to understand how systems will perform beyond what historically was directly measured through experiments. Modeling and simulation tools will now enable them to engineer facilities that have even greater margins of safety than we know of today.

Energy Innovation Hub for Modeling and Simulation

Program Budget		
EIH – Modeling and Simulation ($ in Millions)		
	FY 2010 Actual	FY 2011 Request
	$21.4	$24.3

GRAND CHALLENGES

Over the last two decades, the world has seen an explosive growth in the power of computers. This is the result of faster computer processors and the ability to have up to hundreds of thousands of these processors working on a single problem. Scientists and engineers are now using this unprecedented computing power to put modeling and simulation on par with theory and experiment. Now, scientists and engineers are able to create entirely new levels of understanding about both the results of physical processes and insights into the physical processes themselves.

The challenge of building this new level of science-based modeling and simulation is bringing together the large number of disciplines needed for a successful outcome. These include physics, chemistry, mathematics, computer science, electrical engineering, and software engineering. In addition, these disciplines must address issues of multi-physics across multiple length and time scales on parallel computers running thousands of program threads across up to 100,000 processors.

SEEKING THE BEST TEAM AND THE BEST APPROACH

As envisioned, the Modeling and Simulation Hub will be a competitively awarded partnership with national laboratories, industry, and academia. It is intended to use the best existing, relevant modeling and simulation capabilities, or develop new ones, to deliver new levels of science-based understanding of nuclear energy technologies. The Hub will employ a cross-disciplinary team of nuclear engineers and scientists, computer scientists, mathematicians, verification and validation experts, and sociologists and psychologists to change the existing user environment.

A well-considered competitive process is a critical step to ensuring success and a Funding Opportunity Announcement was released in early 2010 to that end. Once that competition is completed and the Modeling and Simulation Hub is established, the winning team will begin to address the intermediate and long-term goals aimed at removing the barriers to transforming advanced nuclear systems into commercially deployable materials, devices, and systems. Exact deliverables will be determined by the winning proposal.

In addition to the Hub, advanced modeling and simulation efforts for the associated research areas within the Office of Nuclear Energy will continue to develop new computational science capabilities from the micro behavioral level of fuels and materials to the macro behavioral level of entire systems such as reactors, repositories, and even entire fuel cycles. This effort, known as Nuclear Energy Advanced Modeling and Simulation (NE-AMS), along with the Modeling and Simulation Hub will provide complementary and essential capabilities to advance nuclear energy technologies.

PLANNED PROGRAM ACCOMPLISHMENTS

FY 2010

- Develop and issue a Funding Opportunity Announcement.
- Select an applicant and award a Cooperative Agreement contract for five years with the possibility of a five-year extension if a high standard of performance is achieved.
- Stand-up the Energy Innovation Hub for Modeling and Simulation, including:

- Hire subject matter experts for required core capabilities and relocate personnel as needed for optimum Hub operating efficiency.
- Prepare the Hub infrastructure including any required renovation of existing buildings, leasing buildings, purchase of research equipment and instrumentation, and installation of state-of-the-art Hub communications and interface capabilities for long distance collaboration.
- Initiate robust interaction with private industry for the collection of requirements from expected users of the nuclear energy engineering environment.
- Initiate educational/training programs for students, post-doctoral fellows, and scientists.

2011

- Continue to work toward achieving the Hub's goals and objectives presented in the winning proposal, consistent with the Hub's funding plan, including cost sharing if applicable.
- Establish an Energy Innovation Hubs Oversight Board to review the progress of the Hub's scientific program and its management structure, policies, and practices.
- Provide ongoing review of the Hub's deliverables and performance.

The new 1.64-petaflop Cray XT Jaguar features more than 180,000 processing cores, each with 2 gigabytes of local memory. The resources of the ORNL computing complex provide scientists with a total performance of 2.5 petaflops.

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