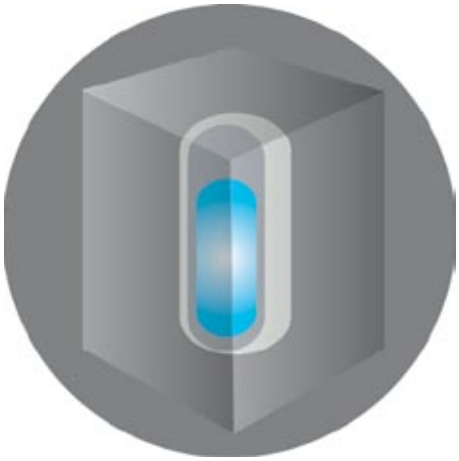

Small Modular Reactor
Demonstration Complex

Concept Paper

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DRAFT

PLUG AND PLAY NUCLEAR REACTORS

Less than one-third the size of conventional nuclear reactors, a new breed of small, inherently safe nuclear reactors will herald an era that can broaden the course of nuclear power. Proven through actual test runs, then templated and produced in factories and shipped by rail or truck, 'Plug and Play' reactors can erase many of the drawbacks of last-century reactors. Today, Savannah River National Laboratory has the desire and means for hosting a Small Modular Reactor Demonstration Complex to accelerate 'Plug and Play' nuclear technology by leap-frogging technical and regulatory hurdles to create new jobs and help assure America's position as a global clean energy leader.

"One of the most promising areas is small modular reactors (SMRs). If we can develop this technology in the U.S. and build these reactors with American workers, we will have a key competitive edge. Our choice is clear: Develop these technologies today or import them tomorrow."
Secretary Steven Chu
March 23, 2010

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BACKGROUND – CHOOSING DAVID OVER GOLIATH

While nuclear power must be part of the solution to the challenges of energy security and climate change, the complete solution is more complex than building lots of large, traditional light water reactors (LWRs). After all about 70% of the countries in the world lack the basic infrastructure to transmit electricity any appreciable distances from large LWRs to end-users. Beyond this, in many developed countries:

- The growth in demand is widely distributed
- The existing electrical grids are bottlenecked, lacking the capacity and flexibility to wheel power between regions
- Environmental and societal concerns often make the construction of new transmission lines more difficult than the construction of new nuclear power stations.

Consequently, small modular reactors (SMRs), which can be located close to electricity consumers, are gaining favor around the world. This spike in popularity is rooted in two characteristics of their design and construction:

- **Small.** SMRs have capacities ranging from 10 Megawatts electrical (MWe) to 350 MWe. As such, they are ideal power sources for isolated locations that require an uninterruptible source of power independent of the electrical grid (i.e., remote villages, oil sands projects, military bases). They also give utility operators in more populated areas greater flexibility to provide inexpensive, incremental additions to baseload electrical generation.
- **Modular.** The modularity of SMRs facilitates manufacturing, assembly, and cold testing in a highly-controlled, factory setting. The results are improved quality, enhanced safety and reliability, lower capital costs, and shorter delivery schedules than field-constructed reactors.

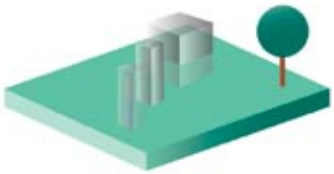
SMRs to the Rescue

Being small, modular and mobile these reactors have many possible applications, including providing needed electrical power after major natural disasters, much the way U.S. Navy carriers, have in similar situations.

Small Packages

True to the old saying about small packages, SMRs offer flexibility that traditional LWR operations simply cannot equal.

Standard LWR Footprint



SMR Footprint

A number of competing designs could be prototyped at SRS in the SMR Demonstration Complex.

Energy Multiplier Module (EM2)
General Atomics
240 MWe, helium gas cooled

Traveling Wave
TerraPower, LLC
300 MWe, liquid-metal cooled

mPower
Babcock & Wilcox
125 MWe, pressurized water reactor

Hyperion
Hyperion Power Generation, Inc.
25 MWe, Pb-Bi cooled

PRISM
General Electric-Hitachi
300 MWe, liquid metal cooled

IRIS
Toshiba-Westinghouse
350 MWe, pressurized water reactor

NuScale
NuScale, Inc.
45 MWe, pressurized water reactor

Pebble Bed Modular Reactor
Eskom (South Africa) and
Toshiba-Westinghouse
80 MWe, helium gas cooled

4S
Toshiba
10-50 MWe, liquid metal cooled

MISSION NEED – SAVANNAH RIVER SITE WILL WRITE THE BOOK

With the exceptions of the B&W mPower and one or two other designs, which are scaled-down versions of proven LWR technology, SMRs are based on generally new technologies that have not been demonstrated at scale. Appropriately, the technical, legal and regulatory issues confronting SMRs are radically different from those faced by their larger LWR brethren.

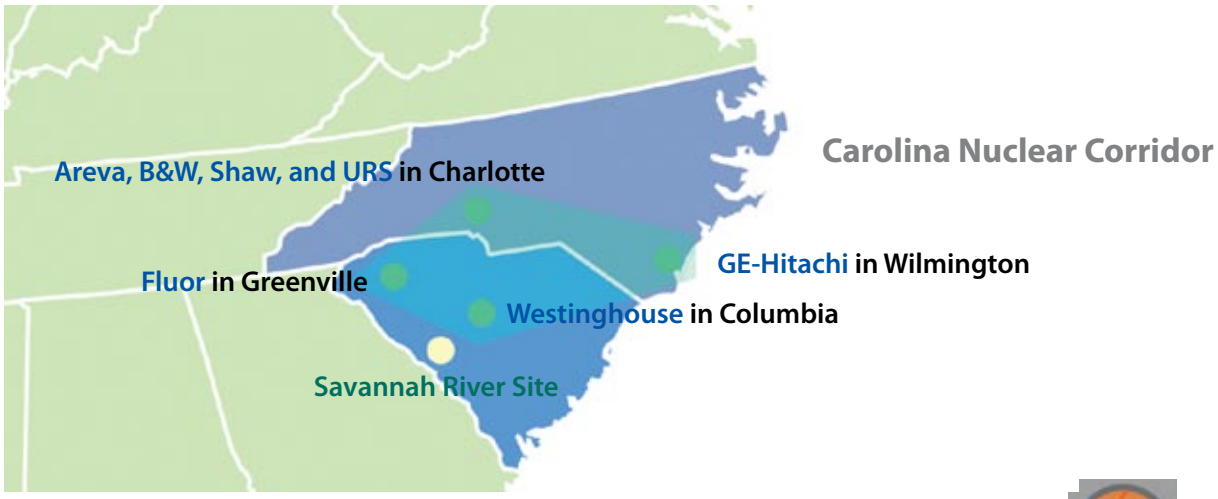
It is widely acknowledged that the Nuclear Regulatory Commission (NRC) is neither sufficiently staffed nor technically informed to begin certifying designs for most SMRs. Consequently, if SMRs are to play a role in the U.S. energy mix any time in the next decade or two, demonstrations of SMRs at commercial scale are needed to resolve remaining technical issues and inform and accelerate the NRC's licensing process.

As was done with LWRs 50 years ago in Idaho, the required demonstrations should occur at a DOE site. Of the available DOE sites, SRS is the preferred choice for the following reasons:

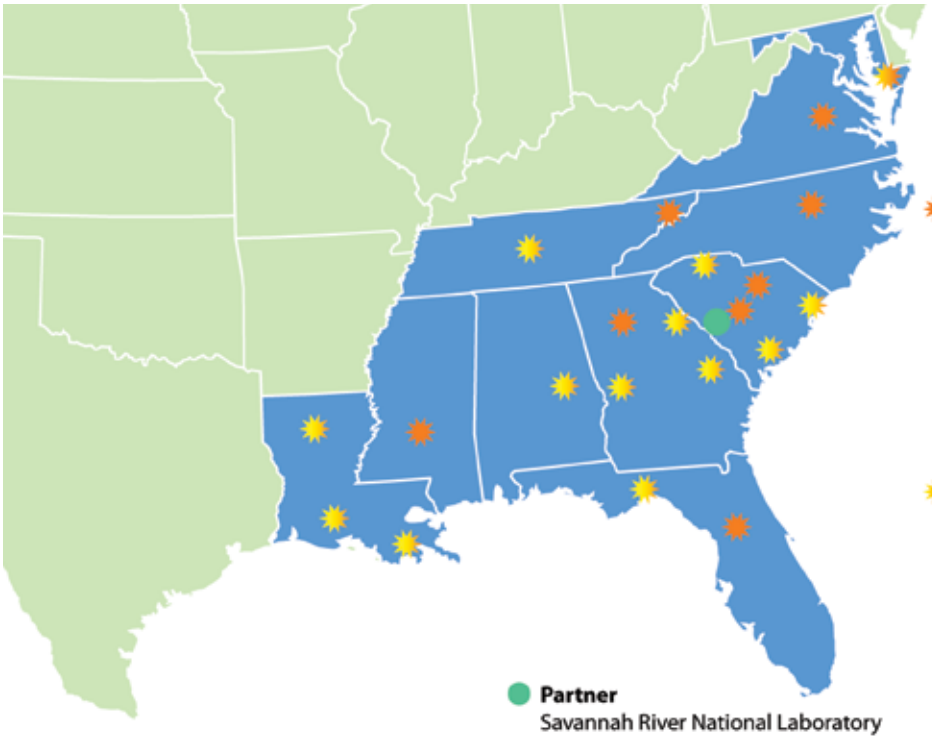
- **Safety Culture** - SRS has the best nuclear safety culture in the Complex; evidenced by an unsurpassed record of safe and effective construction and operation of nuclear reactors and fuel cycle facilities

- **Infrastructure** - SRS has the Savannah River National Laboratory, DOE's premier applied engineering laboratory, underutilized land and infrastructure ideally suited to the SMR demonstration mission

- **Logistic** - SRS is located in close proximity to the Carolina Nuclear Corridor (Charlotte-Wilmington-Columbia-Greenville) in which the domestic nuclear EPC and manufacturing industries are consolidating. The logistical convenience of having these resources so close together is clear, especially when considering transporting personnel or materials.



- **Jobs** - Approximately six thousand near-term construction jobs and five thousand long-term operations jobs locally and tens of thousands jobs nationally will be created. More than just the individuals employed, the impact on the surrounding economy would be monumental as it provides an exciting new, long-term purpose of truly national importance for the Savannah River National Laboratory—a purpose perfectly in line with its proven competencies.
- **Education** - Nuclear education has been largely neglected in the U.S. for the past 30 years and most of the skilled nuclear workforce is approaching retirement age. A large number of universities have banded together under the Southeast Universities Nuclear Reactors Institute for Science and Education (SUNRISE) to meet the challenge of training the next generation of U.S. nuclear engineers and operators. SMRs at Savannah River National Laboratory would provide SUNRISE with the facilities needed for the required "hands-on" aspects of the curricula.



Southeast Universities Nuclear Reactors Institute for Science and Education (SUNRISE)

University Members
Georgia Institute of Technology
Mississippi State University
North Carolina State University
South Carolina State University
University of Florida
University of South Carolina
University of Tennessee
Virginia Tech

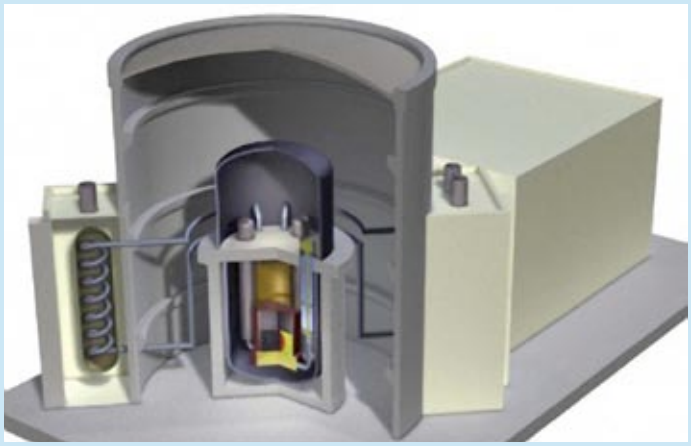
Potential University Members
Clark Atlanta University
Clemson University
Francis Marion University
Florida State University
Louisiana State University
Louisiana Tech
Medical College of Georgia
Medical University of South Carolina
Tulane University
Tuskegee University
University of Georgia
University of Maryland
Vanderbilt University

In addition to all these reasons, there is also the simple fact that this would serve as a needed stepping stone to creating the U.S. Energy Freedom Center. SRNL has conceptualized the U.S. Energy Freedom Center™ as a long-term Energy Park vision for SRS. The U.S. Energy Freedom Center™ is a hybrid, carbon-neutral production platform for hydrogen and synthetic transportation fuels in which the SMR Demonstration Complex could supply all of the required process heat and electricity.

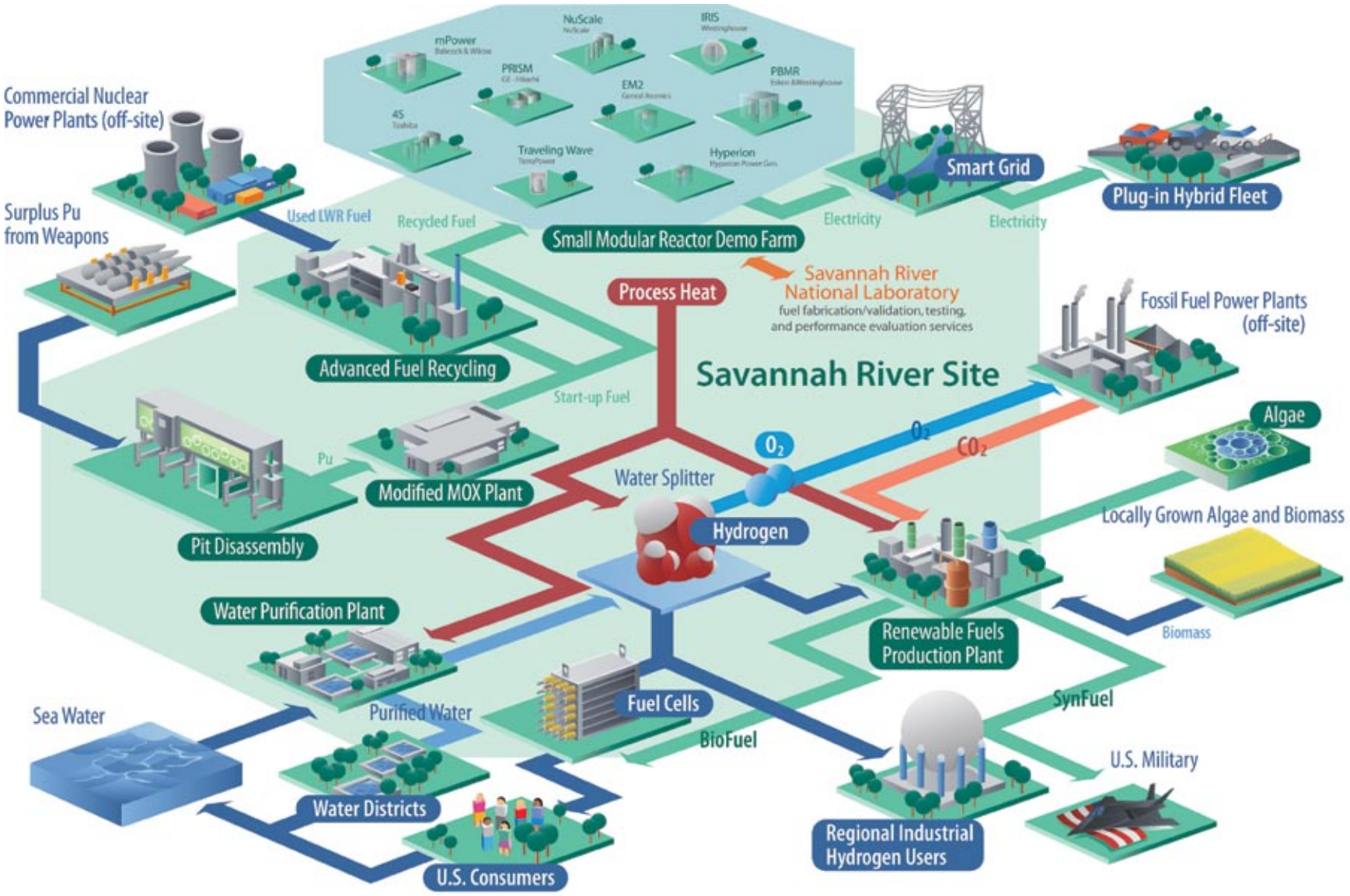
The ambitious scope and technical complexity of the U.S. Energy Freedom Center™ mandate an incremental approach to its development and deployment. In this regard, the SMR Demonstration Complex is the sensible first step.

International Opportunities & National Interests

Without significant changes in regulation and priorities, the SMRs will likely be developed and initially deployed overseas and the American technologies and high-paying jobs will be lost. This trend is already emerging as Bill Gates, the force behind TerraPower, recently announced that he is in discussions with Toshiba to build the TerraPower Traveling Wave SMR in Japan.



"Our choice is clear: Develop these technologies today or import them tomorrow."
Steven Chu - US Secretary of Energy
Wall Street Journal
March 23, 2010



U.S. EnergyFreedomCenter™

Hybrid Nuclear-Synfuels Platform for Sustainable Energy Independence

Applying existing technologies synergistically in one location can provide America with a quantum leap in global clean energy leadership.

IMPLEMENTATION – MAKING IT HAPPEN

The SMR Demonstration Complex would be a collaborative effort of DOE, SRNL, and industrial concerns (General Atomics, GE-Hitachi, Toshiba-Westinghouse, TerraPower, B&W, NuScale, Hyperion, and others) to:

- Demonstrate, at industrial scale, the economic and environmental benefits of SMR technologies
- Provide design, construction, and operational data on SMRs to inform and dramatically shorten the NRC licensing process; accelerating by up to a decade the time in which SMRs can reach commercial markets in the U.S.

A portion of the SRS reservation would be set aside for the construction of a test bed (i.e., reactor farm). This reactor farm would function as a "user" facility for the accelerated incubation of SMR technology. Industrial concerns would construct and operate prototypes of various SMRs side-by-side under DOE, rather than NRC, purview; the paradigm pioneered at Idaho National Laboratory 50 years ago which jumpstarted the deployment of hundreds of LWRs in the U.S. and around the world in the latter half of the 20th century.

Within the test bed, the design, construction, and operation of the SMR would be demonstrated in parallel with the NRC licensing process. This would effectively remove NRC rulemaking and licensing from the critical path of commercial deployment; enabling schedule savings of up to 10 years.

The first SMRs to be demonstrated would likely be the mPower, IRIS, and the NuScale designs, which are based on LWR technologies. With full commitment of DOE and industry, these could be operational at SRS in 5 years. Other SMRs, which require more extensive fuel development and R&D, would have longer deployment programs. Nonetheless, the deployment schedules of all SMRs would benefit from prototyping in the SRS test bed.

A Tradition of Excellence

These measures and timeline may sound ambitious, until you consider the history of the American nuclear program, especially its naval history. Combining safety and innovation, without compromising either, the U.S. Navy has proven smaller reactors can be safely operated and changed the course of the Cold War as a direct result.

EXPECTED OUTCOMES AND BENEFITS

The principal expected outcome of the SMR Demonstration Complex is demonstrating the commercial and sustaining environmental viability of small modular nuclear reactors. Distributing the costs of emergency planning, security, utilities, infrastructure and other services across the entire fleet will greatly reduce the costs associated with the development of individual SMR designs. Additionally, demonstration of the SMRs under DOE purview, in parallel with the NRC licensing process will significantly reduce the duration and cost of the latter. The bottom line will be improved cost competitiveness and shorter time to market for U.S. SMR technology. Other expected benefits are listed below.

EXPECTED OUTCOMES AND BENEFITS SMR DEMONSTRATION COMPLEX AT SRS

Commercial Viability

- Economical fabrication in U.S. factories
- Quality, reliability and safety better than large LWRs
- Competitive capital and O&M costs on a kW-hr basis
- Compatibility with the existing national electricity grid

Sustainable Energy Independence

- Abundant electricity and process heat with zero GHG emission
- Higher fuel burn-up rates, lower waste volumes
- Used LWR fuel recycling in some designs (EM2 and Traveling Wave)

Human Capital

- 5,000 to 6,000 near-term jobs in design and construction at SRS
- 3,000 to 5, 000 long-term jobs in O&M at SRS
- Tens of thousands of high paying nuclear jobs across the U.S.
- Training of the next generation of nuclear talent—SUNRISE connection

Leveraged SRS Assets

- Compelling energy security and climate change mission for SRNL
- Beneficially reuses existing SRS infrastructure
  - Roads and grounds
  - Utilities systems
  - Facilities (K-Area cooling tower, L-Area fuel storage, etc.)
- Redeploys nuclear-trained SRS workforce post-Recovery Act.

SUMMARY

SMRs provide America a number of unprecedented opportunities, including:

- Enduring energy security
- Reducing GHG emissions
- Revitalizing the manufacturing infrastructure
- Recovering global competitiveness
- Creating tens of thousands of high-paying jobs in engineering, construction, and manufacturing.

These opportunities will be squandered unless government and industry join together with dispatch to avert their loss to the Asians and Europeans. Concerted and immediate effort is needed, beginning with the accelerated construction and commissioning of a SMR Demonstration Complex at SRS.

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