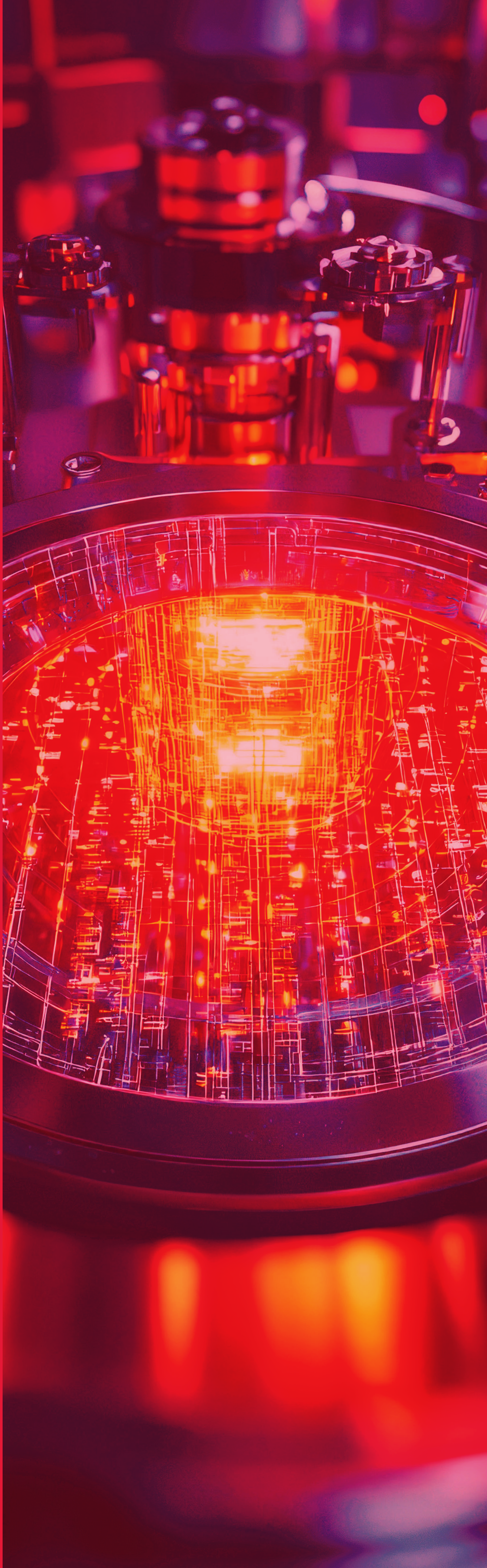
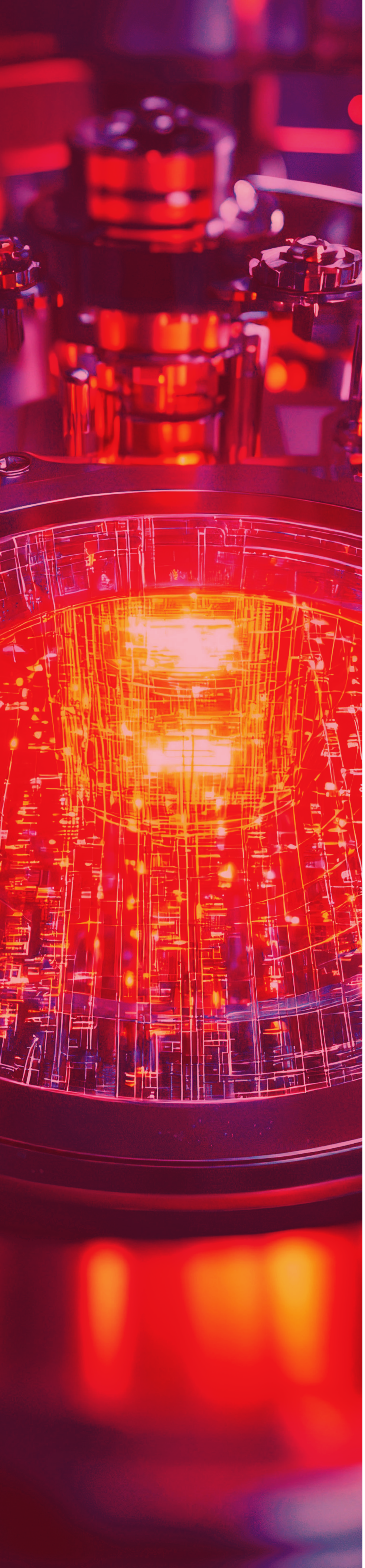
NC STATE UNIVERSITY

FUELING NORTH CAROLINA

A Feasibility Study for a New Advanced Research and Test Reactor at NC State





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EXECUTIVE SUMMARY

The North Carolina General Assembly directed NC State to conduct a study to assess the feasibility of establishing a new advanced research and test reactor (RTR) at the University. This study is an important first step toward better positioning NC State – and, in turn, North Carolina – to be a national leader in advanced nuclear technology and to move the country toward global energy dominance and security. An advanced RTR will help support the state's power ecosystem and spur the innovation required to manufacture and deploy smaller, cheaper, and safer nuclear power reactors in North Carolina. This work has the potential to generate $1-2 billion in annual revenue for the state. For more than 70 years, NC State has safely operated a research reactor program, producing technology advancements and nuclear industry workforce.

The 2022 CHIPS and Science Act authorized $390 million to fund up to four advanced research reactors on university campuses. Being selected for this funding and building a new advanced RTR at NC State would help ensure North Carolina remains a national leader in implementing nuclear power as a clean, efficient, and affordable energy source.

Preferred Technology and Site Selection

NC State, supported by industry expert Hatch, recommends a multipurpose advanced sodium-cooled mixed/coupled spectrum design as the technology for the new advanced RTR. This multipurpose reactor would be a unique facility — the only sodium-cooled fast research and test reactor in the country. The proposed site for the advanced RTR is at the southwestern tip of Centennial Campus (just east of the intersection of Main Campus Drive and Trailwood Drive).

Next Steps

With the support of the North Carolina General Assembly, NC State recommends proceeding with Advanced Planning. ***This phase of work will include:***

Reactor design

- Estimated cost: $10M ($5M/year for two years)

Surveys, site characterization, safety and environmental assessments, and preliminary facility design

- Estimated cost: $2.4M ($1.2M/year for two years)

Regulatory and stakeholder engagement

- Estimated cost: $600K ($300K/year for two years)

The amount of funding required to support this scope of work is $6.5M per year over a two-year period, for a total of $13M. Additional state funding will build on the momentum gained during the feasibility study and help create the foundation for a robust preliminary design that ensures all functional, safety, and operational requirements are fully integrated into the project from the outset.

Most importantly, this crucial phase of the project will help position NC State as a ***strong contender for federal funding*** and will level the playing field with competing universities that have already completed the preliminary design phase.

OVERVIEW

For more than 70 years, NC State has safely operated a light-water-moderated nuclear research reactor program, equipping graduates with practical skills and the experience needed to fuel our state's economic development. Supported by our research, education, and training, this program directly produces technology advancements and nuclear industry employees.

At the direction of the North Carolina General Assembly, NC State has conducted a study to assess the feasibility of establishing and operating a new advanced RTR. This study is an important first step toward better positioning NC State – and, in turn, North Carolina – to be a national leader in advanced nuclear technology, and moving the country toward global energy dominance and security.

Electrical power is crucial for continued economic growth across the state. The availability of reliable, affordable electricity strengthens North Carolina by:

- Driving industrial productivity
- Attracting businesses
- Sustaining innovation
- Stimulating growth in the service sector

An advanced RTR at NC State will help support the state's power ecosystem and spur the innovation required to manufacture and deploy smaller, cheaper, and safer nuclear power reactors in North Carolina. This work has the potential to generate $1-2 billion in annual revenue for the state, according to the latest regional and state-level analysis by E4 Carolinas, the trade association for energy companies in North and South Carolina.

Why Build the NC State Advanced RTR Now?

Building the advanced RTR at NC State is the first step toward developing the technology that will make nuclear energy a scalable, sustainable, and affordable energy source. ***Nuclear energy will be a key part of a sustainable energy future, and the NC State advanced RTR will create opportunities for:***

- Developing the technologies and fuel we need to power small modular reactors and advanced reactors.
- Informing the use of small modular reactors to support AI data centers, manufacturing, power generation, and industry across the state.
- Strengthening North Carolina's position as a leader in technology, and in particular, making our state an incubator for new technology companies that will grow around Generation IV nuclear.
- Serving as a testbed for developing thermal energy storage technologies to maintain a resilient and diverse energy grid.
- Building the advanced nuclear energy workforce and training the next generation of engineers and scientists for various STEM-based careers.

Building a new RTR at NC State will help ensure North Carolina remains a national leader in implementing nuclear power as a clean, efficient, and affordable energy source.

In the following pages, we outline our recommendations and present more details on our proposed plans and considerations for the next steps, which include additional investment from the state, to best position NC State – and North Carolina – for federal funding.

NUCLEAR ENERGY LANDSCAPE AND BENEFITS TO NORTH CAROLINA

The Southeastern United States boasts a substantial group of companies with significant experience in nuclear power production. The region plays an important role in developing new nuclear technologies that are emulated worldwide. An advanced RTR at NC State will offer the Southeast a generational opportunity to help develop a clean energy system while maintaining low costs and meeting reliability goals.

As older reactors in the region — and in North Carolina — reach the end of their useful lives, new reactor construction must meet or exceed the energy-generating capacity of the reactors being decommissioned. Small modular reactors will help speed up that process and create additional resiliency for the overall power system in the state and across the Southeast. The availability of an advanced RTR will further strengthen North Carolina's position as an industry leader as the need for clean, reliable energy grows.

The nuclear industry makes sizable and unique contributions to North Carolina's economy. ***According to a recent report by energy trade association E4 Carolinas, the nuclear industry's economic impact on the state includes the following:***

5,384 *direct employees*	*Support of* **15,494** *additional jobs across the state*	**$4.9B** *in annual economic impact*	**$367.5M** *in state tax revenue annually*

Moving the Industry — and North Carolina — Forward

A new advanced RTR on NC State's campus, as recommended by the feasibility study and outlined in the following pages, will support and accelerate the deployment of advanced small modular reactors in North Carolina. By bridging research, industry, and education, the facility is essential to positioning the state as a leader in clean energy innovation, addressing critical challenges in energy security and decarbonization, and spurring economic development.

Nuclear energy currently provides 14% of North Carolina's nameplate electric power capacity, and the RTR will support exploring new ways to expand utilization. Partnerships with North Carolina utilities can help integrate advanced nuclear systems into the state's grid, creating a cleaner and more reliable energy supply. Training programs and workforce development already established at NC State ensure the state has the talent needed to operate and maintain advanced reactors, supporting long-term energy sustainability.

What Industry Partners Are Saying

> *"The importance of this project for the State of North Carolina and the nuclear industry in North Carolina and across the U.S. cannot be overstated. The Gen. IV reactors are of sufficiently different form and type from the previous light water reactors that many of the existing nuclear industry workforce as well as new workers will need training and education on how these reactors operate. Having the first Gen. IV reactor on NC State's campus will make the university a central technology hub for accelerated deployment of advanced SMRs [small modular reactors] involving researchers and industry partners from the state, the nation, and around the world for decades."*
>
> **Dr. John Zino**
> Chief Consulting Engineer, Advanced Plant Technology, GE Hitachi Nuclear Energy

> *"Duke Energy sees value in North Carolina State University leading an effort to bring a mixed-spectrum research reactor to North Carolina and the United States. NC State has played a key role in supporting existing reactors through its PULSTAR research and related programs. The addition of a mixed-spectrum test reactor could offer valuable insights to the industry as it advances deployment of next-generation reactor technologies. The proposed NC State reactor enables research to further develop fuel cycle technology by enhancing neutronic modeling, refining uranium fuel utilization, transmuting hazardous transuranics into short-lived fission products, and providing operational learning opportunities. There is currently no mixed-spectrum test reactor in the U.S. and thus research supporting a closed-loop fuel cycle is uniquely positioned to support the deployment of advanced reactor technologies, which will enable clean, efficient, and safe power into the future."*
>
> **Chris Nolan, P.E.**
> Vice President, New Nuclear Generation Strategy and Regulatory Engagement, Duke Energy

> *"Nuclear power is poised to play an increasingly vital role in providing low-carbon, affordable, reliable energy. As the home to great universities that are developing new technologies and training the next generation of professionals in the industry, North Carolina is uniquely positioned to support nuclear energy's future. Advanced test reactors like the one that NC State is pursuing will be crucial to supporting these new designs and the workforce operating them."*
>
> **Craig Stover**
> Senior Program Manager, Advanced Nuclear Technology, Electric Power Research Institute

PULSTAR

NC State has been leading the way in nuclear research since 1953, when the first academic research reactor in the world — the Raleigh Research Reactor (R1) — opened on NC State's campus.

Today NC State's innovative engineers use the R-4 PULSTAR — the fourth reactor to be commissioned and operated at the university — to learn, teach, and collaborate on leading research. We're rising to the challenge of determining how we can implement advanced nuclear power as a clean electricity source. The NC State reactor is one of two PULSTAR reactors built, and the only one still in operation.

TECHNOLOGY SELECTION

To discuss the requirements that should drive the selection of the appropriate technology for the advanced RTR, NC State, supported by industry expert Hatch, brought together more than 100 stakeholders from industry, government, national laboratories, and universities. Our goal was to consider the needs of the state, potential industry and academic partners, federal funding partners, national laboratory collaborators, and NC State's interdisciplinary research community. We worked with these experts as well as NC State engineers, researchers, and administrators to explore potential technology for the NC State advanced RTR.

Key considerations:

- Safety
- Site requirements
- Overall supply chain, including fuel
- Environmental impacts
- Occupational safety and health
- Logistics
- Impact and value for innovative research and testing

Potential technologies considered:

- Light water reactors
- Sodium-cooled fast reactors
- High-temperature gas-cooled reactors
- Lead-cooled fast reactors
- Molten salt reactors

As a result of these discussions, NC State has selected the multipurpose advanced sodium-cooled mixed/coupled spectrum RTR as the technology for the university's new advanced RTR.

The sodium-cooled fast reactor (SFR) is a Generation IV advanced reactor technology that aligns ideally with the objectives of the CHIPS and Science Act and the US Department of Energy's strategic directions. Light water-based reactors do not offer new capabilities that have not already been explored and executed by other research reactors in the United States.

This multipurpose reactor would be a unique facility — the only SFR research and test reactor in the country.

This reactor would allow the demonstration of nuclear power's sustainability, given the university's goal of having it in operation for 50-70 years. It also has the potential to support a molten salt loop and tank for demonstrating thermal storage and power generation concepts. In addition, it has the potential for microgrid demonstration. The SFR is the most mature Generation IV technology.

Four other universities are considering applications to the Department of Energy under the CHIPS and Science Act.

- Abilene Christian University, in partnership with Natura Resources, is experimenting with using molten salts, rather than water, as a coolant for nuclear reactors with the goal of designing and building the first university-based molten salt research reactor.
- The University of Missouri is focused on expanding its existing flux-trap-type light water reactor to enhance critical medical isotope research and production for cancer treatments and theranostics.
- The University of Illinois at Urbana-Champaign, in partnership with the Ultra Safe Nuclear Corporation, is applying for a license to construct and operate a demonstration high-temperature gas reactor.
- Penn State University, in partnership with Westinghouse, is demonstrating Westinghouse's eVinci microreactor technology, which is a solid core heat pipe-cooled reactor.

HOW THE SODIUM FAST REACTOR WORKS

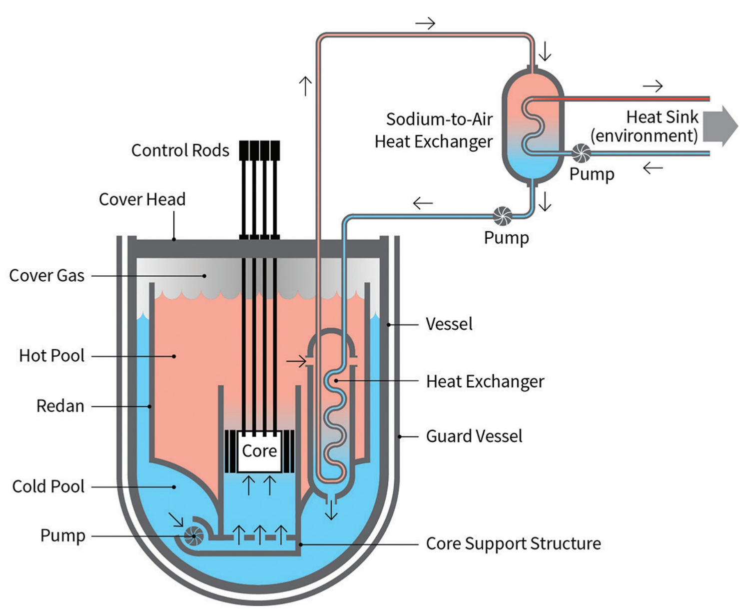

Figure 1. Schematic of the proposed sodium fast reactor system for the NC State advanced RTR.

Figure 1 shows a representative schematic of NC State's SFR system. The core of the SFR contains metallic fuel (U-10Zr). In the reactor design we are proposing, this fuel will be enriched to contain up to 19.75% U-235. Within the core, atoms split to generate energy as heat. The control rods are a bundle of B4C pins in a stainless steel cladding. When the rods are inserted into the core, they absorb neutrons and slow the fission chain reaction. As low-pressure liquid sodium from the cold pool is pumped through the core, the sodium is heated by the fissioning fuel and flows into the hot pool. An intermediate heat exchanger removes the heat to a secondary heat exchanger. Heat from the secondary heat exchanger can be released into the environment or stored in a thermal storage system, such as a molten salt loop and tank.

The secondary heat transfer loop and exchanger keep air and water from interacting with the primary sodium, effectively providing a redundant separation from potentially activated material. The secondary sodium is not radioactive. The inert cover gas also prevents chemical reactions between the primary sodium and air. The reactor vessel has a steel structure (the redan in figure 1) that keeps the hot pool separated from the cool pool. The reactor has both an internal reactor vessel and a surrounding guard vessel. If the reactor vessel should fail, the guard vessel contains the sodium and keeps the core covered and heat removal systems operational.

SAFETY

The advanced RTR will have significantly enhanced safety as compared to the current PULSTAR and commercial light water reactors. NC State will implement safety using “defense in depth,” which provides multiple levels of prevention and protection against the release of radioactive materials by using proven technology, active engineered safety features such as control rods, and well-trained professional operators.

In addition, the safety case of the advanced RTR will be enhanced by:

1. **Safety-in-design** This approach integrates safety considerations at every stage of the advanced RTR design process, including the “fail-safe design principle” that ensures that in the event of a system failure, the reactor transitions to a safe state to protect public health, reactor personnel, and the environment.
2. **Walk-away nuclear reactor safety** The reactor remains safe and stable without requiring human intervention, external power, or mechanical action for extended periods, even in the event of an emergency.
3. **Physics-based self-sustaining mechanisms** Passive safety features such as gravity and natural circulation help ensure unparalleled levels of reliability.
4. **Higher redundancy** The advanced RTR will have three effective means of shutdown, whereas PULSTAR and light water reactors only have two.
5. **Superior safety performance** Fuel and cladding safety measures ensure a comfortable margin to avoid melting under all scenarios.
6. **Inherent negative reactivity feedback** As the temperature rises, regardless of the cause, the reactor’s reactivity is reduced. This effectively makes the fission chain reaction unsustainable and reduces the reactor’s power. The reactor is self-regulating and will always default toward a stable state, ensuring the safety of operators and the environment.
7. **Enhanced heat transfer performance** This feature allows for efficient management of residual and decay heat, which can be stored in the primary coolant for extended periods of time and can easily be managed through the establishment of natural circulation (one of the reactor’s passive safety features).

8. **Two vessels** The function of the guard vessel is to contain the primary sodium in the highly unlikely event that the reactor vessel starts leaking. The gap between the guard vessel and the reactor vessel is sized such that an inspection of the vessels can be performed. However, the height of sodium in the pool would remain sufficient to ensure proper cooling of the core.
9. **Fire safety** The reactor has a dedicated sodium fire protection system. Suppression of liquid sodium fires is accomplished by a built-in, passive system.

SITE SELECTION

Our team began with a wide region of interest, encompassing more than 100,000 acres of university-owned land across North Carolina. Following screening processes outlined in technical reports from the Electric Power Research Institute and guidelines from the Nuclear Regulatory Commission (NRC), sites were evaluated against a range of safety and environmental criteria. Exclusionary criteria were developed to screen out sites with critical habitat for threatened and endangered species, watershed protections, significant wetland extent, or critical flood or fault hazards. This thorough analysis resulted in a range of candidate areas within the main campus precincts that met the safety and environmental criteria for siting an advanced RTR.

These areas were then evaluated against criteria related to student access, environmental impact, and infrastructure. Compatibility with other uses and alignment with the university's Physical Master Plan were also considered. The southwestern tip of Centennial Campus (just east of the intersection of Main Campus Drive and Trailwood Drive) was identified as the preferred location for the advanced RTR site.

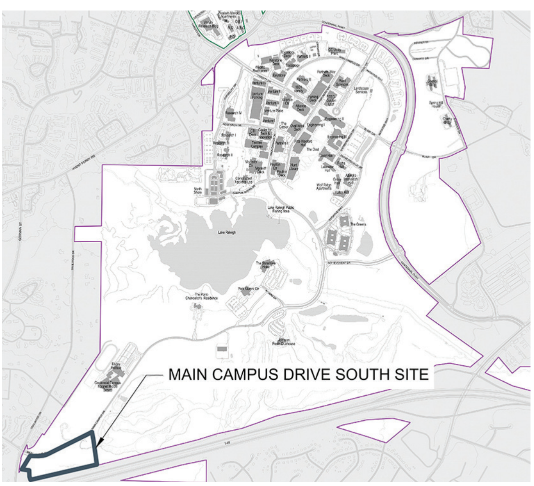

Figure 2. Main Campus Drive South Site

This approximately 16-acre site, referred to as Main Campus Drive South Site (figure 2), has been identified as a location for NC State engineering research for more than 20 years. An advanced RTR is compatible with this vision and also supports the 2023 Physical Master Plan's characterization of the site as a neighborhood of high-bay research space. As noted in the Physical Master Plan, this site provides adequate space for large vehicle entry and exit, can be developed using simpler construction methods, and provides space that allows for testing and research that requires separation from other academic uses.

Main Campus Drive and Trailwood Drive form the north and west boundaries of the site. The university's landscaping staging/laydown area is located across Main Campus Drive, while apartment complexes are located across Trailwood Drive. Lonnie Poole Golf Course is located directly to the east; Centennial Campus Magnet Middle School, the Friday Institute, and the NC State chancellor's residence (The Point) are located further to the northeast. Interstate 40 runs parallel to the southern boundary of the site (figure 3), and there is residential development to the south of the interstate. The risk of relatively high traffic and hazardous material transport along I-40 will be evaluated during the licensing process.

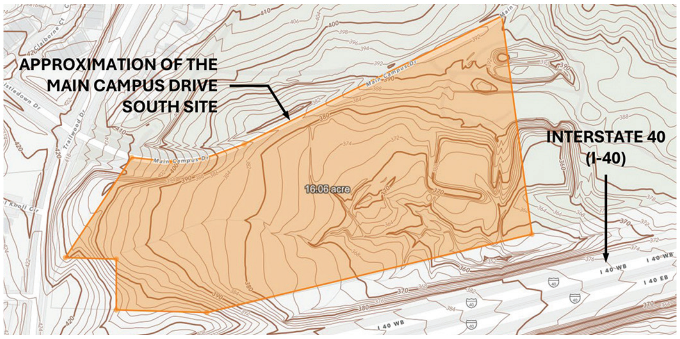

Figure 3. Topographic and location details for Main Campus Drive South Site

The conceptual plot plan (figure 4) shows the advanced RTR facility covering approximately five acres of the site. The facility is separated into a nuclear side and a non-nuclear side. The nuclear side contains the reactor itself (housed in the reactor building) and all systems pertaining to its safe and reliable operation. The nuclear side is protected by a site boundary compliant with NRC requirements and general security requirements. The non-nuclear side consists of an administration building and neutron beam hall, as well as site access roads and parking.

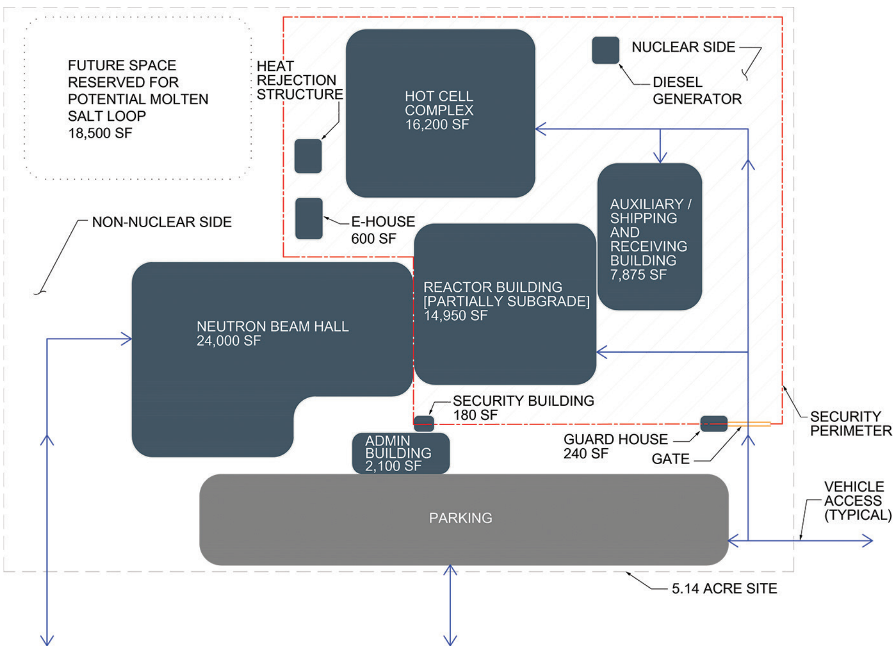

Figure 4. Conceptual plot plan

The Emergency Planning Zone (EPZ) is defined as an area where predetermined protective actions would be taken in the event of a potential release of radioactive materials due to an off-normal condition at the facility. The EPZ for the RTR facility is expected to be limited to the nuclear side. As part of the licensing process, the EPZ will be calculated and analyzed in compliance with the methodology approved by the NRC.

The site will require federal and state permits to address environmental impacts. Two constructed catch basins to the east of the site were identified in the National Wetlands Inventory; however, these are not designated by the State of North Carolina. As part of federal and state permitting processes, field surveys will be conducted to document intermittent streams, determine whether a wetland is present, and document any use of the site by listed and migratory bird species.

As with any nuclear facility, NC State's advanced RTR will generate radioactive waste throughout the facility's life cycle. Any waste produced will be disposed of according to the applicable regulations. Waste management systems will ensure the safe handling, storage, and disposal of all waste types while maintaining safety and environmental standards.

PRE-CONCEPTUAL COST ESTIMATES AND PROPOSED TIMELINE

The project is in the pre-conceptual design phase, and there will be significant design, estimation, and engineering work to complete as part of the next steps. To develop a high-level, pre-conceptual cost estimate, the team relied on similar project experience, cost estimating guides, and references from Argonne National Laboratory and Idaho National Laboratory. Equipment is a major component of the cost of a nuclear reactor facility. While building costs were estimated on a square footage basis, major equipment was identified and sized to establish an opinion of probable cost.

Input from industry representatives indicated that reference cost estimating is the most accurate method for early-phase nuclear projects. Therefore, the estimate was also validated against a reference project of similar scope, the OPAL 20-megawatt multi-purpose reactor in New South Wales, Australia.

$284M	+	**$116M**	+	**$104M**	=	**$504M**
Hard Cost of Work		*Associated Design and Construction Costs (soft costs)*		*Contingency*		*Total Cost*

The total capital cost for NC State's facility is estimated at $504 million. This figure represents the current cost of construction, construction contingency, design fees.

The proposed work includes site preparation; design; licensing; construction of the reactor building, hot cell complex, and neutron beam hall; and construction of supporting structures and infrastructure. ***Cost drivers for the project include the following:***

- Custom-designed reactor, as NC State's advanced RTR will be the only one of its kind
- Applications and capabilities requiring novel approaches
  - Research reactor based on a SFR with mixed spectrum capabilities
  - Beamline integration into a SFR
- Licensing effort that requires significant upfront design work to prepare a Preliminary Safety Analysis report for the NRC construction permit
- Establishment of a quality program, which is a requirement for nuclear reactor design and construction
- Limited market of qualified nuclear contractors
- Complexity and level of engineering required

The proposed construction start date is estimated at July 2029, with an end date of June 2034.

HOW THE ADVANCED RTR WILL BE USED

NC State's advanced RTR will have many potential uses, including:

- The development of environmentally friendly sources of clean, reliable, and affordable electricity
- The redevelopment and advancement of the U.S. microelectronics industry by providing imaging and testing for chips
- Non-destructive examination of materials (e.g., using neutron and radiation beam techniques)
- Limited research production of radioisotopes for industrial and medical use
- Forensic and transmutation irradiation and testing to study damage mechanism for materials and support nonproliferation
- Applications in fundamental science (e.g. fundamental nuclear physics, chemistry, etc.)
- Development of nuclear propulsion for deep space exploration
- Training of the next generation of engineers and scientists for STEM-based careers

Specific research capabilities include neutron imaging and fuel development. Neutron imaging is complementary to X-ray imaging. The lighter the material, the easier it is for X-rays to penetrate it. However, neutron radiation can pass through dense materials more easily than through light materials, which makes it a good option for imaging items with dense outer casings (see figures 5 and 6 for example use cases).

NC State could also focus on supplying high-temperature process heat to industries that traditionally rely on fossil fuels for heat-intensive processes. The advanced RTR can produce heat at temperatures well above those achievable by traditional light water nuclear reactors, making it well-suited for applications such as hydrogen production, desalination, chemical manufacturing, and materials processing.

This facility will support workforce development and industry deployment of advanced nuclear energy in North Carolina and beyond by compressing the timeline necessary to deploy small modular advanced nuclear reactors. Thus, it will ensure the long-term stability of our state's energy environment.

Figure 5. Neutron imaging of soybean roots in situ in a column of soil.

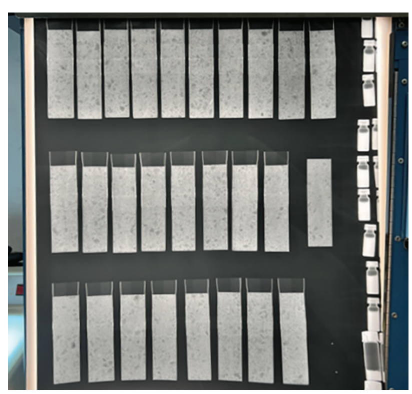

Figure 6. Neutron imaging examining concrete samples for damage under multiple conditions.

PROCUREMENT AND PARTNERSHIPS

Our team conducted a domestic supply chain evaluation to develop a procurement outlook for major components of the RTR. Many U.S. companies are working on commercializing their own proprietary SFR design, including General Electric Hitachi (GEH) and TerraPower. There are also several institutions across the country with expertise in SFR technology, including private entities like GEH, Arc Clean Technology, and Oklo, and public entities such as Argonne National Laboratory and Idaho National Laboratory. As with any project at NC State, we will endeavor to select the most qualified design firm and expertise to help us ensure success.

In addition to continuing the development of nuclear energy infrastructure and advancing clean energy technologies, the execution and completion of this project will enable NC State to establish meaningful partnerships and meet a strategic need for the nation. Potential opportunities for collaboration include utility companies, other universities, and national lab partners. ***We plan to collaborate with the following entities:***

National Lab Partners

- Argonne National Lab
- Oak Ridge National Lab
- Idaho National Lab
- Savannah River National Lab

University Partners

- Virginia Tech
- Virginia Commonwealth
- University of Florida
- Purdue
- South Carolina State
- Cape Fear Community College
- Wake Tech Community College
- NC A&T
- University of Tennessee
- University of Michigan
- University of South Carolina *(proposed)*
- MIT *(proposed)*

LICENSING REQUIREMENTS

Licensing requirements for advanced RTRs are governed by national regulatory agencies, principally the NRC. These requirements ensure that research reactors are designed, operated, and decommissioned safely, protecting public health and the environment.

Given the mission of NC State’s proposed advanced RTR, the university can obtain a license under the Atomic Energy Act section 104c pursuant to 10 CFR 50.21(c) as a University Research Reactor facility. The advanced RTR design proposed does not currently impose any feasibility issues, but it does require significant work and engagement with the NRC to prepare a thorough construction permit application. Abilene Christian University has recently used this framework to acquire construction permits for its advanced reactor design.

Early design work on NC State's advanced RTR should begin to prepare the Preliminary Safety Analysis Report, with early NRC engagement on key design topics. Additionally, field activities should start to support the environmental report preparation.

NEXT STEPS

With the support of the North Carolina General Assembly, NC State recommends proceeding with Advanced Planning.

The Advanced Planning phase will involve the following work:

Reactor design

- Preliminary design work on key components (such as the reactor vessel and hot cells) to validate and further develop the cost estimate
- Core design and neutronics studies
- Thermal-hydraulics, safety transient analysis, and heat removal design studies
- Estimated cost: $10M ($5M/year for two years)

Surveys, site characterization, safety and environmental assessments, and preliminary facility design

- Initial site development plan
- Surveying and stormwater/grading design
- Site assessment and infrastructure planning
- Further development of the project budget, including quotes from vendors for major components, identification of proposed funding sources, and determination of project delivery method
- Preliminary safety analysis report
- Environmental impact assessment
- Estimated cost: $2.4M ($1.2M/year for two years)

Regulatory and stakeholder engagement

- Pre-engagement with the NRC
- Development of white papers and technical reports
- Stakeholder communications and public outreach
- Development of consortium, with the goal of developing a proposal in anticipation of the Department of Energy Funding Opportunity Announcement
- Estimated cost: $600K ($300K/year for two years)

The amount of funding required to support this scope of work is $6.5M per year over a two-year period, for a total of $13M. Additional state funding will build on the momentum gained during the feasibility study and help create the foundation for a robust preliminary design that ensures all functional, safety, and operational requirements are fully integrated into the project from the outset.

Most importantly, this crucial phase of the project will help position NC State as a strong contender for federal funding and will level the playing field with competing universities that have already completed the preliminary design phase.